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SECTION 603 – CULVERTS AND STORM DRAINS

603.1 – GENERAL

The primary purpose of a drainage system is to provide adequate means of channeling run-off and surface water so as to prevent damage by water, which either directly or indirectly is the cause of many roadway failures. It is an easy relation to understand that the more water that remains under the roadway the more frost action that will be observed. The two basic functions of buried pipe are hydraulic and structural capacity. Careful consideration to both as well as economics is advised prior to making any changes to drainage plans. Most drainage is one of the first operations to occur, any field changes should be made as soon as possible. The project personnel need to check the condition of existing pipes, calculating the elevations and slopes with the finish grades of the roadway, and check the drainage schedule for the appropriate lengths and sizes. This will assure that only the required amount of drainage materials are ordered and will avoid any cost associated with unneeded pipes, basins, or labor. The Contract Administrator must ensure that the designer's requirements are fulfilled during construction so that a satisfactory installation will result. There is more to drainage than just getting water to flow. Between the unexpected field conditions that can be encountered, and the differing pay limits involved with each drainage run, familiarization with the Plans, Standard Specifications, Special Provisions, and the Construction Safety Manual is encouraged prior to constructing any Item contained in this section. It is in the best interest of the Department and the Contractor to be pro-active to avoid potential conflicts with the various conditions associated with the project.

603.2 – MATERIALS

Various materials are used in the manufacture of culverts and storm drains, mainly reinforced concrete, corrugated metal, and plastic. The Standard Specifications contain the material requirements, but also refer to various governing AASHTO Specifications. Following is some information from AASHTO and NHDOT Specifications that is useful in checking pipe. Certificates of Compliance must be submitted to the Contract Administrator at the time of delivery.

A. Reinforced Concrete Pipe

1. Field check data. See the table on the next page.

2. Reinforced concrete pipe should be delivered to the project only after it has cured sufficiently to be transported without damage to the pipe. Check the date of manufacture as marked on the pipe and the date of delivery, for conformance to the minimum age as required by the Specifications.

3. Design criterion. Whenever it becomes necessary to relocate a reinforced concrete culvert to a position having a greater cover height than that shown on the plans, the following design standard should be utilized:

Maximum Height of Fill over Pipe m (ft)	Normal Construction (kPa)	Imperfect Trench (kPa)
3.9 (13 ft)	100 (2000D)	
6.0 (20 ft)	150 (3000D)	
10.5 (35 ft)		150 (3000D)
15.0 (50 ft)		200 (4000D)
22.5 (75 ft)		250 (5000D)

Normal construction refers to excavating the trench to the elevation of the bottom of the pipe and then preparing and shaping the bottom of the trench to fit the lower 10% of the external diameter of the pipe as required by specification. Backfill, in lifts not exceeding 6 inches, and hand chink under the entire length of the pipe while backfilling the bottom 1/2 the height of the pipe. Backfill shall be compacted by air or vibratory tools.

Design Requirements For Reinforced Concrete Pipe

Internal Diameter		Wall Thickness (mm)													
		100 kPa (2000-D)						150 kPa (3000-D)				175 kPa (3750-D)			
Size	Variance (Max.)	Wall Type A		Wall Type B		Wall Type C		Wall Type B		Wall Type C		Wall Type B		Wall Type C	
mm (in)	mm (in)	Min.	Design	Min.	Design	Min.	Design	Min.	Design	Min.	Design	Min.	Design	Min.	Design
300	310	39	44	45	50	-	-	45	50	-	-	45	50	-	-
12”	3/16	1 9/16	1 3/4	1 13/16	2			1 13/16	2			1 13/16	2		
375	390	42	47	52	57	-	-	52	57	-	-	52	57	-	-
15”	7/32	1 11/16	1 7/8	2 1/16	2 1/4			2 1/16	2 1/2			2 1/16	2 1/4		
450	465	45	50	58	63	-	-	58	63	-	-	58	63	-	-
18”	9/32	1 13/16	2	2 5/16	2 1/2			2 5/16	2 1/2			2 5/16	2 1/2		
600	620	58	63	70	75	-	-	70	75	89	94	70	75	89	94
24”	3/8	2 5/16	2 1/2	2 13/16	3			2 13/16	3	3 9/16	3 3/4	2 13/16	3	3 9/16	3 3/4
750	775	64	69	83	88	-	-	83	88	102	107	83	88	102	107
30”	3/8	2 9/16	2 3/4	3 5/16	3 1/2			3 5/16	3 1/2	4 1/32	4 1/4	3 5/16	3 1/2	4 1/32	4 1/4
900	925	70	75	95	100	113	119	95	100	113	119	95	100	113	119
36”	3/8	2 13/16	3	3 13/16	4	4 1/2	4 3/4	3 13/16	4	4 1/2	4 3/4	3 13/16	4	4 1/2	4 3/4
1000	1080	83	88	107	113	125	132	107	113	125	132	107	113	125	132
42”	13/32	3 5/16	3 1/2	4 9/32	4 1/2	5	5 1/4	4 9/32	4 1/2	5	5 1/4	4 9/32	4 1/2	5	5 1/4
1200	1230	95	100	119	125	137	144	119	125	137	144	119	125	13	144
48”	15/32	3 13/16	4	4 3/4	5	5 15/32	5 3/4	4 3/4	5	5 15/32	5 3/4	4 3/4	5	5 15/32	5 3/4
1350	1385	107	113	131	138	149	157	131	138	149	157	-	-	149	157
54”	17/32	4 9/32	4 1/2	5 7/32	5 1/2	5 15/16	6 1/4	5 7/32	5 1/2	5 15/16	6 1/4			5 15/16	6 1/4
1500	1540	119	125	142	150	161	169	142	150	161	169	-	-	161	169
60”	19/32	4 3/4	5	5 11/16	6	6 13/32	6 3/4	5 11/16	6	6 13/32	6 3/4			6 13/32	6 3/4
1650	1695	131	138	155	163	173	182	155	163	173	182	-	-	173	182
66”	21/32	5 7/32	5 1/2	6 3/16	6 1/2	6 7/8	7 1/4	6 3/16	6 1/2	6 7/8	7 1/4			6 7/8	7 1/4
1800	1850	142	150	166	175	184	194	166	175	184	194	-	-	184	194
72”	23/32	5 11/16	6	6 21/32	7	7 3/8	7 3/4	6 21/32	7	7 3/8	7 3/4			7 3/8	7 3/4

B. Corrugated Metal Pipes and Pipe Arches

Field check data. (Compiled from AASHTO M 36M/M 36 Type I or II for Steel and M 196M/M 196 for Aluminum.)

1. Circumferential shop-riveted seams shall have a maximum rivet spacing of 6" (150 mm) except that six rivets will be sufficient for 12" (300 mm) pipe.

2. The center of all rivets shall not be closer than twice their diameter from the edge of the metal.

3. Longitudinal seams shall have one rivet in the valley of each corrugation, except that for 42" (1000 mm) culvert and over must be double riveted.

4. Corrugations in aluminum pipe shall be 68(2.5") by .5" (13 mm).

5. Bituminous coated corrugated steel pipe and pipe-arches (compiled from AASHTO M 190 Type C) shall be uniformly coated inside and out with asphalt cement to a minimum thickness of .05" (1.3 mm) and 25% of the circumference of a pipe shall be paved at least 1/8" (3.2 mm) above corrugations to form a smooth surface.

6. The lapped longitudinal seams of riveted or resistance spot-welded pipe arches shall be staggered so as to alternate not less than 10% of the periphery.

7. Causes for rejection:
   - a. Uneven laps.
   - b. Elliptical shaping.
   - c. Variation from a straight centerline.
   - d. Ragged or diagonal sheared edges.
   - e. Loose, unevenly lined, or unevenly spaced rivets.
   - f. Defective spot welds or continuous welds.
   - g. Poorly formed rivet heads or lock seams.
   - h. Unfinished ends.
   - i. Illegible brand.
   - j. Dents and bends in the metal itself.
   - *k. Bruised, scaled, or broken spelter coating.
   - *l. Lack of rigidity.

*NOTE: Applies to corrugated steel pipe only.

The Standard Sheets contained in the back of the Plans provide information concerning the gage of steel pipe required for various heights of cover above the top of the culvert. These tables should be consulted when adding or changing culverts from that shown on the Plans.

C. Plastic Pipe

The plastic pipe should be checked to assure that the interior walls are smooth and not corrugated.
The sections are true to form and not bent or bruised.
The flanged ends are constructed properly to accept the adjoining section of pipe.
All current AASHTO criteria shall be maintained.

603.3 – CONSTRUCTION OPERATIONS

A. General

The proposed drainage system as shown on the Plans is usually designed from survey notes taken long before construction begins. The location of pipes should be checked prior to construction operations. Due to the actual conditions found during construction, the original design may not be satisfactory and changes may be needed. Such conditions may be the presence of utilities which should be thoroughly checked prior to structure excavations so any permissible adjustments in line or grade may be made. If a pipe is to be moved, added, deleted, or the size changed, have the necessary data and reasons for substantiation in order that authorization may be granted by your District Construction Engineer. Always study field conditions carefully and double check planned and adjusted locations and grades. It can not be overstated how important it is to make revisions to the drainage system as early as possible so that the Contractor is notified prior to ordering pipe and drainage structures. Be sure Right-of-Way is notified of changes in drainage flowage rights.

Although the contractor is ultimately responsible for the drainage lay-out, it is important to understand the procedure used in order to eliminate any unnecessary errors at the start of operations. When staking drainage, it should be kept in mind that any lay-out should define the line and grade of the structure. The position of offset stakes will depend on field conditions. Cross pipes are usually staked by referencing the ends to establish line and grade. Pipes running longitudinally along the construction line (such as underdrain and carrying pipes) can be staked by using the station side stakes as a reference for line and grade. Independent checks should be made on all construction stakes relative to information given on these stakes. On skewed pipes, set slope stakes on either side of the pipe and compute the slope elevations to insure that the ends of the pipe will fit the slope. The location of the stakes relative to the pipe line should be determined in conference with the Contractor. Recognizing the Contractor's type of operation and construction procedure often eliminates a duplication of stake placement. When laying out drainage, have sufficient pipe reference stakes and check the computations before marking the stakes. Generally, the information marked on a pipe reference stake is: 1) the size and type of pipe, 2) the vertical distance from the top of the hub to the flow line at the end of the pipe, 3) the horizontal distance from the hub to the end of the pipe, and sometimes, 4) the gradient or pitch. This list is intended only as a guide since various Contractors, Contract Administrators, and field personnel have equally acceptable methods.

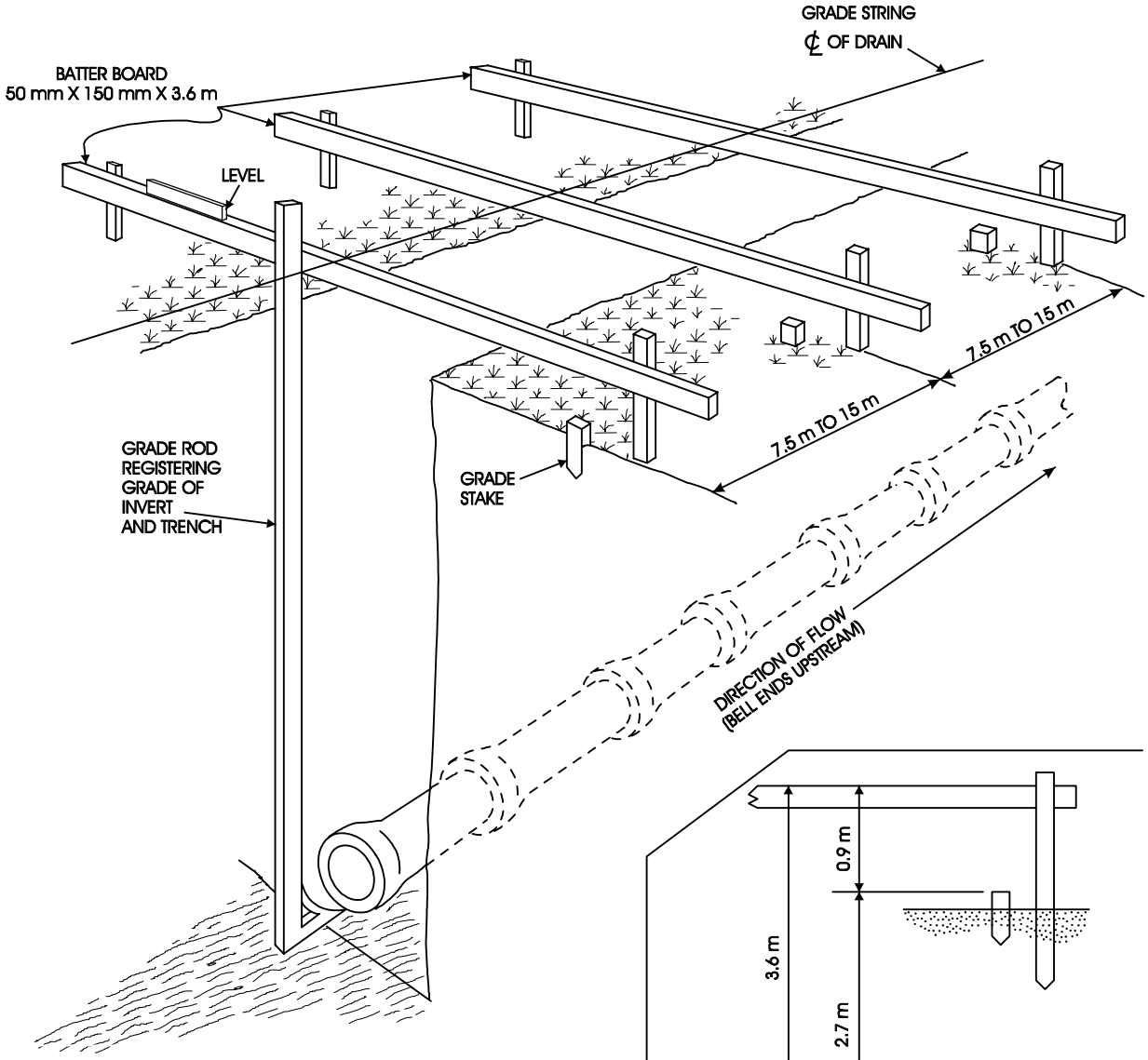
The Contractor may elect the method of installation as long as acceptable results are obtained. Figure 1 on the following page illustrates the use of batter boards. This method of pipe lay-out is seldom used in today's fast paced construction environment, however the fundamentals discussed are still the same.

The objective of the batter board system is to set a parallel line above the pipe trench at the grade of the pipe run. This is done by figuring the grade at each location of the batter board, and setting the batter boards a certain set distance above the pipe. A string is run over the boards so that a grade can be checked at any location along the pipe run. The Contract Administrator and/or field personnel can easily utilize these basics when checking a drainage operation with a pop level and six foot ruler. Grades should be figured to the bottom of the trench, and with the level transfer a grade from an offset hub.

Figure the cut required at your location, measure the distance to see how the trench compares to your computation.

The use of a laser is far more common. The laser is usually set at the low end of your drainage run. The grade is dialed into the laser to set the beam. As the crew digs the pipe trench they can immediately see where their excavation lies relative to the laser beam. Some of the problems that can occur with the laser are that on long runs the beam can be distorted, and the laser can be easily knocked out of alignment. For these reasons it is important to continually check your operation so that the plan grades are achieved.

Before the actual installation, the pay limits for each run should be reviewed. It is important to check the original cross-sections for accuracy and in areas not covered by sections take old ground data before the area is disturbed so that computations of quantities may be possible. In general, excavations up to 9 ft are subsidiary to the pipe, any depth over 9 ft is an extra pay. There are similar limits with catch basins and drop inlets. If ledge is encountered then sections must be determined by plotting the top of ledge and the bottom of the pipe trench to determine the correct quantity to be paid. These are just some of aspects of drainage that the field personnel need to be familiar with, as previously stated, the contract specifications need to be reviewed before any drainage run is started. It is impossible to review the operation after old ground is disturbed and the pipe is buried.



The length of the grade rod is optional as long as it is the sum of the distance from the top of the stake to the flow line of the pipe plus the distance from the top of the stake to the top of the batter board.

The illustration at right shows a 3.6 m grade rod, with a 2.7 m cut on the grade stake to the flow line of tile.

3.6 m -2.7 m = 0.9 m

Therefore the batter boards will be set 0.9 m above the grade stake.

Figure 1: Batter Boards

Cross pipes should be cambered if possible, generally from 3" (75mm) to 6" (150 mm) depending on the fill height over the top of the pipe and the compressible character on the foundation soil. After installation adequate fill over the top of the pipe is required to prevent damage to the installed pipe by heavy equipment.

The inspector should see to it that the Contractor complies with all safety regulations currently incorporated in the Contract in regard to bracing and shoring of trenches. OSHA regulations do apply and regulators have the ability to levy fines. Project personnel should be familiar with safety codes and should immediately notify the Contractor if any unsafe practices are observed. A trench can be a trap, and neglecting trench shoring to speed construction can lead to a tragedy. Care shall be taken that the width of the trench shall not exceed that specified in the Standard Specifications since loads on pipes increase when trench widths increase.

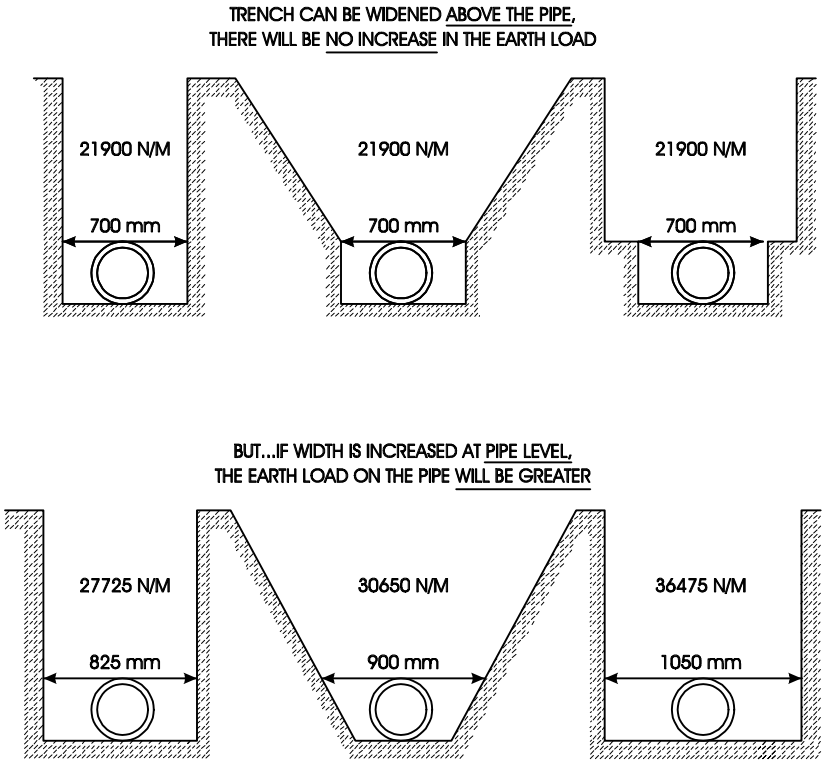
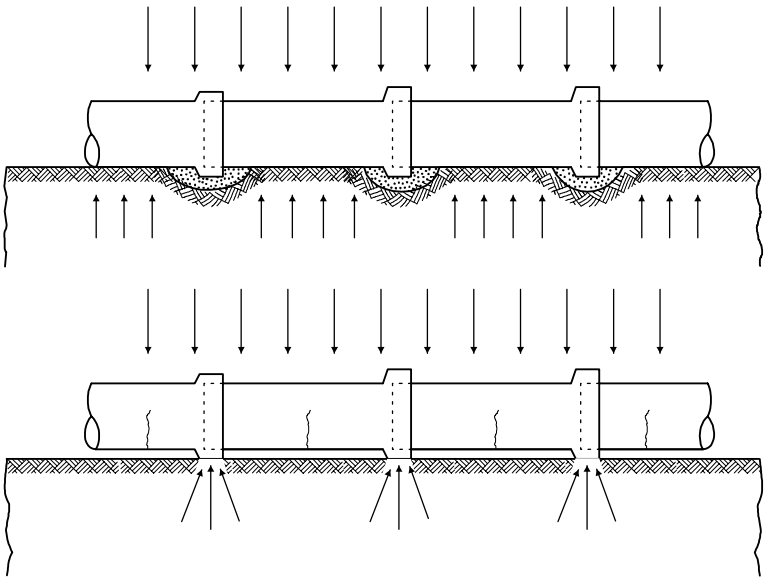


Figure 2: Proper Trench Widening Methods

B. Bedding

The load delivered to a pipe from above by the weight of the overlying soil or some surface load must be delivered by the pipe to the underlying soil. If firm support of the pipe by underlying soil is established only over a narrow width, as with a round pipe in a flat bottom trench, the intensity of the load beneath the pipe will be large and failure is more likely. Some means of establishing firm support of the pipe over a wider band will reduce the load intensity beneath the pipe. This same effect may occur with bell and spigot pipe if it is placed without cutouts for the bells.

EFFECT OF BEDDING



PIPE INSTALLED WITH AND WITHOUT CUTOUTS FOR BELLS

Figure 3: Proper Bedding Methods for Pipes

The inspector can help ensure a good job by seeing that the Contractor's personnel understand the need for proper bedding.

If it can be avoided, culverts should not be placed partly on filled ground and partly on undisturbed natural ground because of the probability of unequal settlement, which might distort or break the culvert. When pipes are installed in embankments, the fills are required to be constructed to a specified height and width on each side of the culvert before installation. Unstable soils, which produce poor supporting conditions, should be removed and replaced with suitable material. Serious cracking sometimes develops in reinforced concrete pipe when rock is closer to the bottom of the pipe than permitted by the Specifications. A coarse gravel bedding containing cobbles may also produce cracking if large cobbles are close to the pipe. The Contract Administrator has the authority to remove and replace the bedding if it is felt that the material is unsuitable.

This is however not subsidiary to the pipe and accurate quantities must be obtained to quantify the extra pay quantity.

The Specifications should be consulted as to the type of bed requirements and trench dimensions for various soil or rock conditions.

C. Laying and Joining

Proper equipment is essential for obtaining satisfactory culvert installations. Methods of laying pipe may differ between Contractors, but the primary concern of the inspector is to see that the finished installation is in compliance with the intent of the Specifications.

Handling pipe shall be done in such a manner as to prevent damage. Pipehooks and slings are permissible methods and the use of eyebolts with nuts utilizing a large washer are also acceptable when lift holes are provided in the pipe. Pipe laying shall begin at the downstream end of the culvert with bell ends or groove ends facing upstream. Never permit the Contractor to attempt to shape the trench bottom by raising and dropping the pipe. Tight joints are possible with the use of a pry bar with suitable blocking to protect the bell or by cable winches. Care should be exercised to prevent the moving of previously placed length when setting a new pipe. It is desirable to avoid having to cut a pipe where it joins a structure. Many times a slight adjustment in location of a planned pipe or minor structure will eliminate this difficulty without interfering with the function of the culvert. The area under each bell section needs to be removed so that the pipe will bear evenly on the pipe trench. In cases where the ground water may invade the pipe run the rubber gaskets may be eliminated between the sections of pipe in an effort to absorb and channelize this surrounding water.

Corrugated metal pipes, when specified, shall be shop-strutted. The life of a corrugated steel culvert depends largely on the care taken to preserve the galvanizing and the asphalt coating.

After laying and joining the culvert, a check by the inspector for proper grade and alignment is encouraged since it is too late after backfilling. This is also the appropriate time to make any necessary measurements.

D. Backfilling

Settlement in fill adjacent to or over culverts is one of the more frequent causes of rough riding surfaces. Another frequent cause is the use of differing material between the pipe trench and the surrounding materials. The frost will act differently on dissimilar materials thus creating a bump over pipe crossings. For this reason it is important use the same material in your backfill operation as you did in your pipe excavation operation. The inspector must see that good compaction is accomplished beside and over the pipe. In the case of flexible pipe, this will minimize pipe deflection. In the case of rigid pipe, it will reduce backfill settlement. In each case this means more uniform pavement support. When backfilling a trench, it should be assured that the backfill placed under the haunches be thoroughly compacted. In narrow trenches there seems to be a tendency to relax the compaction requirements. These requirements must be met to obtain the adequate lateral support necessary to successfully tolerate the loading to which a pipe

may be subjected. Where backfill under haunches and along sides of concrete pipes has not been properly placed and compacted in accordance with Specifications, distress can occur with resulting cracks in the inside top and bottom of pipe. The use of water to help consolidate these difficult areas and to obtain the optimum moisture content should be encouraged. To ensure against disturbance of the pipe alignment, each lift of backfill material will be placed and compacted uniformly on each side of the pipe.

E. Imperfect Trench

When a culvert is to be covered with a high fill, the pipe must be protected from the weight of the fill. The imperfect trench method achieves this requirement by a trench excavated over the top of the installed culvert and refilling with the excavated material, uncompacted, to form a cushion. The remainder of the embankment then proceeds normally. The compacted material over the cushion carries the load from the fill above it to the sides of the trench by arch action. This arch action takes a great deal of the load off the pipe and helps prevent the pipe from being crushed. Some serious pipe distresses have resulted when pipes were backfilled and then the fill was not completed above the trench for a considerable period. In these cases, the imperfect trench backfill material was partially compacted by the combined action of construction traffic and weather thus reducing the effectiveness of the method.

SECTION 604 – CATCH BASINS, DROP INLETS, AND MANHOLES

604.1 – GENERAL

Catch basins and drop inlets are the entrance structures that collect water from pavements, loam areas, and most ditch lines.

Catch basins will be used where water flow is relatively slow and a sump is required to collect sediment, thus keeping pipes in the system clean. Catch basins range in size, generally over 6’ tall with a 2.5’ to 3’ sump.

Drop inlets will be used where water flow is rapid enough to make the system self-cleaning; for this reason the size of a drop inlet is approximately 4’, but can vary depending on the size of the outlet pipe.

Manholes will be used where a structure is required to provide entrance to a pipe due to long length, where a number of pipes must join, and where an angle must be made in a run, all where surface water entrance at the location is not required.

604.2 – MATERIALS

All materials should be inspected prior to being incorporated into the work. The inspector should also be assured that all materials have been approved for use in the work and that all the required certificates of compliance have been received. The Standard Specifications and the Standard Sheets attached to the Plans should be consulted for familiarization of requirements.

Based on information received from concrete structure manufacturers, the following table lists the standard hole sizes cored into catch basins for RCP and plastic pipe. This information should be used to help select the proper diameter for a catch basin or manhole that has multiple pipe runs set in and out of the structure. The recommended minimum inside diameter spacing between two cored holes is 12" (0.30 m); 7" (0.18 m) if one of the pipes is underdrain. This minimum spacing is very important in order to maintain the structural integrity of the basin especially when 3 or more pipes are in the structure and where larger diameter pipes are used resulting in the cored hole being more than 6 inches (0.15 m) greater than the size of the pipe. If the basin only has one inlet and one outlet pipe, the 12" (0.30 m) minimum spacing guideline may be reduced because there will only be one potential weak spot in the structure that can be reinforced with a proper brick and mortar application between the two pipes.

INFO. FOR DETERMINING CATCH BASIN SIZE

	RCP			PLASTIC PIPE		
PIPE SIZE	WALL THICKNESS	CORE HOLE SIZE		WALL THICKNESS	CORE HOLE SIZE	
inches	Inches (mm)	Inches	Feet (m)	Inches (mm)	Inches	Feet (m)
12	2.00 (51)	18	1.5 (.46)		18	1.5
15	2.25 (57)	22	1.8 (.55)		20	1.7 (.51)
18	2.50 (64)	26	2.2 (.67)		24	2.0 (.61)
24	3.00 (76)	34	2.8 (.85)		32	2.7 (.81)
30	3.50 (89)	42	3.5 (1.07)		42	3.5 (1.07)
36	4.00 (102)	48	4.0 (1.22)		48	4.0 (1.22)
42	4.50 (114)	54	4.5 (1.37)		54	4.5 (1.37)
48	5.00 (127)	64	5.3 (1.62)		64	5.3 (1.63)
54	5.50 (140)	72	6.0 (1.83)			
60	6.00 (152)	78	6.5 (1.98)			

604.3 – CONSTRUCTION OPERATIONS

Careful attention to grades and positioning during layout is essential; otherwise the catch basin or drop inlet will not fit the curb or the ditch alignment, a condition, which makes maintenance and cleaning operations difficult or impossible. This is especially troublesome where a basin is located next to a curb radius. In this situation the radius must be laid out accurately to be certain of the correct location of the basin. If a basin is at a low point it should be checked by plotting a profile of the pavement as it joins the curb, and adjusting the basin to the exact low point if necessary. If during construction a structure has been improperly located, consideration should be given to have it corrected before curbing and paving are placed. Where grades are generally flat, even a properly positioned basin at the low point may result in puddles on either side of the grate, so the grates should be set 2" (50 mm) lower than the pavement grade instead of the usual 1" (25 mm). Pay close attention to the pavement so that it tapers smoothly to the grate with no puddles. Grates should be set to their final grade after the binder course has been

placed. This binder course provides the grade and pitch for the grate. Recently, the plans have been calling for the addition of a plastic liner between the frame of the grate and the basin. Be sure to insert the liner at the time you set the frame to grade. Pour the area around the basin to within 2"-3" of the top of the grate with concrete, locking the basin, the liner, and the frame together as one. Contractors often would like to use gravel, hot top, or something else, other than concrete but these materials will usually settle and should not be allowed. Manhole positioning is essential since placement of manhole covers should not be in conflict with curb lines. When laying out sanitary sewer structures, it should be noted that the center of the sewer is not necessarily the center of the top opening in the structure, and the final grade of the manhole cover should be flush with the top course of pavement. The methods of installation of these structures differ, but for the ease of setting catch basin sumps and manhole bases, try to get them set before laying the last length of pipe. During installation, the inspector should observe or check all takeoff measurements made by the workers. Walls of structures should be constructed plumb and the dimensions of the structures should reasonably conform to that required. Careful attention should be paid to the backfilling operations to be sure no damage occurs to the structure and also to be sure compaction of the backfill material is obtained.

SECTION 605 – UNDERDRAINS

605.1 – GENERAL

Underdrains are used to lower a high water table, and to intercept and dispose of water seeping into the roadbed.. Underdrain consists of perforated pipe and granular backfill that will readily pick up and carry off water from the roadway, thus creating a more stable roadbed and minimizing differential frost action. These two components act together to help divert the underlying water away from your roadway. The underdrain sand itself must meet the required gradation, and generally for the first 1 ft over the pipe be uncompacted to allow for water filtration. If a spring or other natural water flow erupts from the subgrade and is not drained by the normal run of underdrain, a special run to this troublesome area is often the best way of controlling the problem.

605.3 – CONSTRUCTION OPERATIONS

Except for special conditions, it is usually simpler and preferable to lay out underdrain with the flow line of a run parallel to the pavement. The typical roadway section sheet and the Standard Sheet in the Plans usually show the minimum distance below subgrade to the top of the pipe and also the minimum distance below pavement to the bottom of the trench. In general this distance is 2.5 ft below subgrade and 15 ft left or right of centerline. In guardrail areas you must be sure to allow enough room to install your posts without interfering with your underdrain run.

When collecting water, lay the pipe with the perforations down. This tends to result in a self-cleaning system. Entering water agitates the fines in the pipe and carries them to the outlet. When the only need is to carry water, such as through a fill section to the outlet, install the underdrain with the perforations up.

Staking: In deep roadway cuts where sidestakes are far from the underdrain, it is generally advisable for the Contractor to run and grade an additional control line from

the original ties as a reference for underdrain and any structures. With proper planning the same stakes can be used for other drainage, as well as subgrade shaping and checking.

SECTION 606 – GUARDRAIL

606.1 – GENERAL

This work includes the construction or resetting of guardrail consisting of beam, box beam, post markers and anchorages. Guardrail should only be used where the result of striking an object or leaving the roadway would be more severe than the consequences of striking the guardrail. Guardrail is an expensive construction item and involves heavy maintenance costs throughout its life. Recent interest in the construction of safer highways has caused redesign and experimentation with different types of guardrail. Therefore, the Contract Administrator should be thoroughly familiarized with the type, location, and quantity of guardrail to be installed on each project. Guardrail and median barrier installations are formidable roadside hazards and provide errant vehicles with only a relative degree of protection. Where these installations are indicated, the roadway should be examined to determine whether flattening an embankment slope or adjusting other site features might eliminate the need for the installation. The design criteria for placing guardrail is different depending on the geometry of the roadway (tangents, curves, shoulders, sideslopes). Before changing any run of guardrail make sure the design specifications and roadway hazards are fully understood.

Portable concrete barriers (PCB) are used to shield motorists as well as workers within the construction zone. Like guardrail, barrier should only be installed where the protective benefits of the barrier outweigh the potential damages if struck. Common uses of PCB are for bridge widenings, shielding of roadside structures, roadway widening, pavement edge drop off, and for separating two-way traffic on one roadway lane.

606.2 – MATERIALS

Most guardrail materials are manufactured off the site, so the inspector should review the required material Certificates of Compliance prior to installation. All materials should be inspected for any damage that may have occurred during transit and handling. Guardrail posts can be either 6 ft or 7 ft in length, depending on the roadway backslope, with no splitting or rotten areas. It is important from a liability stand point that the 7 ft post are installed at the proper locations. The post shall be set such that the top of the metal rail is 28” above the grade at edge of pavement. End units and special rails may have a different height.

Portable concrete barriers (PCB) must meet the requirements of NCHRP Report No. 350. In order to achieve crashworthy effectiveness, PCB sections must be properly connected to one another and in some cases, anchored to the underlying surface to prevent lateral movement (ex. phase bridge deck construction).

606.3 – CONSTRUCTION OPERATIONS

A. Locations

The Contract Administrator should review each location of guardrail as shown on the Plans. It is difficult for a designer to accurately determine the final locations. Field personnel should become familiar with current Department policy on the location of guardrail, then field check the locations prior to staking, thus allowing for adjustments in lengths and locations. If large differences are anticipated, the Contract Administrator should obtain authorization from the District Construction Engineer before proceeding with the layout.

Portable concrete barrier should be placed at a minimum offset of 2 ft. (0.6 m) from the traveled lane wherever possible (9.2.1.1.2 AASHTO Roadside Design Guide). The MUTCD also recommends that PCB not be placed more than 12 to 15 ft. (3.6 to 4.6 m) from the edge of the roadway to reduce the potential of high-angle impacts.

B. Layout

The project personnel can set stakes for the limits of the guardrail installations. This will help to visualize the rail lengths relative to the hazard. The pavement centerline should be established to align the guardrail posts. A careful check should be made to see that the guardrail is located at the proper distance from the shoulder or pavement. Proposed locations should also be checked for conflict with underground utilities. Several different staking techniques may be employed, the choice of which will be determined by the Contractor. These range from offset stakes to offset tacks indicating line and grade. A check with the Contractor to determine their method of operation will often prevent a conflict between the layout location and the necessary positioning of the construction equipment and excavated material. The Contractor should also be thoroughly informed as to the meaning and method of layout.

Guardrail should be properly placed to minimize the possibility of a vehicle running behind the installation into the hazard zone. Although the Plans indicate the location of guardrail by station number, the Contract Administrator should tentatively stake the location and adjust those stakes to the actual field location that will afford passing vehicles the most coverage. The Contract Administrator may find that the end points should be extended so that the approach end is not a hazard to oncoming vehicles. Remember, liability wise it is easier to add lengths to a guardrail run than it is to take lengths away.

In some instances, field conditions may require that the designed guardrail layout be changed due to unforeseen obstacles in the planning phase. One method used to minimize the length of rail needed, or to reduce the amount of grading required to build a flat approach to the terminal is to flare the rail. This means installing the rail at a taper away from the edge of the road or shoulder so that it no longer runs parallel with the road. Be aware that the greater the flare rate, the higher the angle of impact and severity of a crash. Flared sections also increase the chance that a vehicle will be redirected back into or across the roadway. This situation is especially undesirable on two-way roadways where the impacting vehicle could be directed onto oncoming traffic (Section 5.6.3,

AASHTO Roadside Design Guide, 2002). The advantages and disadvantages of flaring the rail must be seriously considered before any change is made.

The following table lists the maximum recommended flare rates per the 2002 AASHTO Roadside Design Guide.

Speed		Shy Line * Offset		Flare Rate	Flare Rate Outside Shy Line *
mph	(km/hr)	feet	(meter)	Inside Shy Line *	
70	(110)	9.2	(2.8)	30 :1	20 :1
60	(100)	7.9	(2.4)	26 :1	18 :1
55	(90)	7.2	(2.2)	24 :1	16 :1
50	(80)	6.6	(2.0)	21 :1	14 :1
45	(70)	5.6	(1.7)	18 :1	12 :1
40	(60)	4.6	(1.4)	16 :1	10 :1
30	(50)	3.6	(1.1)	13 :1	8 :1
* Shy line is the distance beyond which a driver will not react to an object near the roadway.					
(Source : Tables 5.5 and 5.7 of AASHTO Roadside Design Guide, 2002)					

There are other variables to consider if the designed guardrail is not going to fit the existing conditions. ELT terminal units installed at the ends of guardrail runs are meant to crush when hit. This means that there must be a sufficient run-out length behind the rail so that if a vehicle runs through the terminal unit it will still have time to come to a stop. This "run-out length" can be anywhere between 130 ft (40 m) and 475 ft (145 m) depending on design speed and traffic volume. Table 5.8 in the AASHTO Roadside Design Guide lists the suggested run-out lengths for guardrail design.

SUGGESTED RUNOUT LENGTHS FOR GUARDRAIL DESIGN									
		Traffic Volume (ADT)							
Design Speed		Over 6000 vpd Runout Length *L_R		2000-6000 vpd Runout Length *L_R		800-2000 vpd Runout Length *L_R		Under 800 vpd Runout Length *L_R	
Mph	(km/hr)	Feet	(meter)	feet	(meter)	feet	(meter)	feet	(meter)
70	(110)	475	(145)	445	(135)	395	(120)	360	(110)
60	(100)	425	(130)	400	(120)	345	(105)	330	(100)
55	(90)	360	(110)	345	(105)	315	(95)	280	(85)
50	(80)	330	(100)	300	(90)	260	(80)	245	(75)
45	(70)	260	(80)	245	(75)	215	(65)	200	(60)
40	(60)	230	(70)	200	(60)	180	(55)	165	(50)
30	(50)	165	(50)	165	(50)	150	(45)	130	(40)
*L_R is the theoretical distance needed for a vehicle that has left the roadway to come to a stop. (Source : Tables 5.8 of AASHTO Roadside Design Guide, 2002)									

It is very important to understand that the flare rates and run-out lengths are given as guidance only to be able to formulate a solution to an on-site problem. It is imperative that the Highway Design Project Engineer be consulted before any proposed changes take place.

The above information refers to permanent guardrail or other permanent barrier installation. The design requirements of temporary portable concrete barrier (PCB) are less stringent than permanent installations primarily because of their temporary nature. The desired treatments of exposed ends of PCB are (1) connecting to an existing barrier, (2) attaching a crash cushion, (3) flaring away to the edge of the clear zone, or (4) burying the end in the back slope.

A common method is (3) flaring away to the edge of the clear zone. The flare rates for temporary barriers should be selected to provide the most cost beneficial safety treatments possible. Low flare rates lead to longer flared sections and increase the number of impacts with the temporary barrier. Higher flare rates lead to shorter flared sections and fewer impacts but, for those impacts, increase the severity of redirection crashes and the number of barrier penetration crashes. Benefit/cost analysis of temporary concrete barriers indicate that total accident costs appear to be minimized for flare rates ranging from 4:1 to 8:1. A flare rate of 5:1 or 6:1 may be slightly more favorable for urban streets with high traffic volumes where speeds are lower and impact angles are higher (Section 9.2.1.1.1, AASHTO Roadside Design Guide, 2002).Once a flare rate is determined, the PCB must be placed beyond the clear zone. The required clear zone is typically found in the Prosecution of Work in the project proposal and contract.

EXAMPLE OF CLEAR ZONE WIDTHS FOR WORK ZONES

Speed		Width from T.W.	
mph	(km/hr)	feet	(meter)
60-70	(100-110)	30	(9)
55	(90)	23	(7)
45-50	(70-80)	16	(5)
30-40	(50-60)	13	(4)

(Source : Table 9.1 of AASHTO Roadside Design Guide, 2002)

C. Construction

Construction details relating to post spacing and locations, dimensions, and other pertinent information are shown on standard detailed drawings which are included in the Plans for the project. Always check Plans for conformity as guardrail detail has been changing rapidly. Note that curves of small radii require a decrease in the post spacing. Generally, the holes for the posts are excavated by auger or hand labor. Posts may be placed by a driving machine provided they are driven plumb to the required depth and alignment with adequate lateral stability and provided the posts, shoulders, and adjacent slopes are not damaged from the driving operations. Much of the problem with guardrail

installation will come during this driving operation. Larger boulders or drainage structures may be encountered. In some cases the only way to continue is to hand dig the obstruction. The Project Personnel must be realistic in their decisions. Double nesting the guardrail or pouring concrete around the shortened posts may be a solution. It is essential that the posts have a firm foundation and that the backfill around the posts be thoroughly compacted to minimize future settlement. When post holes are over-excavated by auger or shovel, the bottom of the hole will be backfilled and thoroughly tamped to grade. Wood posts should be inspected for damage caused during placing because exposure of untreated wood subjects it to attack by fungi and insects, which in turn causes further weakening of the posts. Steel posts should be driven in such a manner as to ensure no spreading, splitting or brooming of the post. Beam rail laps should be made in the direction of vehicular traffic. The final step is to install the guardrail delineators. This spacing should be closer than the standard roadway delineation, to accentuate the guardrail run, but the actual lay-out should be specified in the plans.

Prior to acceptance, each section of guardrail should be inspected for its effectiveness and also for line and grade by observing the guardrail from several viewpoints. Include driving the road in each direction, to make certain it serves the intended purpose and that the grade and alignment are pleasing to the eye, particularly at bridge approaches. Existing guardrail to be reset should be carefully removed from the old location and reset at the designated locations. Resetting of guardrail should meet the same requirements as construction of new guardrail.

D. Measurement

The Plans and Specifications should be consulted for the proper limits of measurements. In the case of resetting the guardrail, a measurement should be taken prior to initial removal to account for possible lost or damaged material at a later date.

SECTION 607 – FENCES

607.1 – GENERAL

The purpose of this Item is to delineate the boundaries of land acquired for public right-of-way, to discourage animals and people from entering the right-of-way area, and to discourage building encroachment upon State property. To accomplish these purposes, it is sometimes beneficial to erect the fence before construction begins. Recent Department fencing policy for Limited or Controlled Access Highways includes the following:

1. Chain Link Fence will be constructed where children or pets may enter upon the right-of-way.
2. Woven Wire Fence will be constructed on the remaining right-of-way.

The above is the Department's policy for specifying fence type; however, the project personnel should build the types specified at locations designated on the Plan or as directed by special Right-of-Way agreements.

607.2 – MATERIALS

The Standard and Special Detail drawings included in the project plans will specify the material requirements. Prior to fence installation, the required material Certificates of Compliance should be submitted to the Contract Administrator. Wire and fabric gauges, post dimensions, material coatings, etc., should be checked and verified by the field personnel before incorporation into the work.

607.3 – CONSTRUCTION OPERATIONS

A. Location

Before fence construction is started, the Contract Administrator should study the Plans with special attention being given to right-of-way lines, control-of-access lines, location of gates, angle points, etc. Fences should not be located so as to obstruct flow in streams or drainage areas where the fences may collect driftwood or other material and cause serious property damage due to backwater.

B. Layout

It is the responsibility of the Contract Administrator to lay out the fence location and it should be done well in advance of the anticipated work to avoid Contractor delays. The Contractor will then layout the individual post locations which should be checked as the fence is being erected for conformance with the Standards and Specifications.

C. Construction

The fence inspector should be thoroughly familiar with the related Plans and Specifications. The inspector should inspect the installation or erection of all items of fencing to ensure that the posts are excavated to the proper depth, erected true to line, that the wire, fabric, and hardware are attached to the posts in the proper manner and at the proper elevation, that the wire is installed on the specified side, and that the posts are firmly installed. Obstructions which interfere with the proper alignment should be removed. Any dead trees that might fall onto the fence should be cut down and removed. Good fence construction practice requires careful attention to line and grade. A string line may be used as a guide to maintain alignment and to eliminate minor variations in the grade of the post tops as the posts are being set in their final position. A carpenter's level may be used to assure that posts are vertical. Concrete used for post bases should be poured slightly above the surrounding ground and rounded on top to drain water away from the post. Wire and fabric should be taut and spaced as shown on the Plans with the specified clearance under the fabric to prevent children and small animals from crawling under the fence.

D. Measurement

The Plans and Specifications should be consulted for the proper limits of measurement. In the case of resetting fencing, a measurement should be taken prior to initial removal to account for possible lost or damaged material at a later date.

SECTION 608 – SIDEWALKS

608.3 – CONSTRUCTION OPERATIONS

The location and grade of a sidewalk is usually dictated by the curb line. Sidewalk locations and grades, especially those not adjacent to curbs, should be staked and checked well in advance of the work.

The Contract Administrator should review the roadway typical section sheets of the Plans to know the design and slope of the sidewalk, particularly in the vicinity of an approach or driveway. Once the sidewalk is constructed, the Contract Administrator should be concerned with the development of the area behind the walk in regard to matching residential lawns, walks, and steps in a practical and aesthetic manner.

Special attention must be given to the location and timing of all utility structure alterations within or beneath the sidewalk so that this work is completed at the proper location and well in advance of the sidewalk construction.

SECTION 609 – CURBS

609.1 – GENERAL

A recent change in slope curb introduces an item of radial joint granite slope curb to provide for curb cut on radial joints with radii of 2 ft (0.6 m) through 15 ft (4.5 m). Curb with 15 ft (4.5 m) radius or less will continue to be curved granite slope curb and over 15 ft (4.5 m) radius will be considered straight granite slope curb even though it may be necessary to field cut joints to fit a radius.

609.2 – MATERIALS

The Specifications are complete as to material requirements and also include a useful chart showing required finished surfaces and allowable tolerances for checking granite curb.

609.3 – CONSTRUCTION OPERATIONS

The curb location should be staked and checked well in advance of the work. Proposed locations of driveways and drainage structures should be reviewed. The Contractor should set a line at the front top of the curb and have the Contract Administrator review it far ahead of any curb setting. Before any set curb is mortared, the line and grade should be sighted and approved by the project personnel. Where a sudden change in pavement crown is encountered, such as where a roadway slope of 2 % meets a bridge slope of 1 %, care must be taken to obtain a transition that will eliminate drainage problems without drastically changing the curb reveal and still give a pleasing grade to the curb and related guardrail. Setting a string line on stakes and sighting the line is a good method to lay out and check such transitions. All curbs shall be set on a thoroughly compacted base.

Excessive excavation without proper backfill and compaction before setting the curb shall not be allowed. This is especially important adjacent to structures.

When an island bounded by curb is to be surfaced with concrete, curb joints should be located at construction joints to allow for shrinkage cracking in the concrete. The curb joints should coincide with the construction joints or the curb is likely to crack beside the construction joints.

Bridge curb is normally adjusted to line and grade by a pair of wedges near each end of each curb. The line and grade must be checked and approved before any mortaring is done. After approval, the bottom of the curb at each end is mortared and allowed to set so the wedges may be removed, then the balance of the bottom of the curb is mortared.

Great care must be taken to insure that all wooden wedges and parts thereof are removed and that the area under the curb is completely filled with mortar. The most acceptable method of mortaring curb is to drive all mortar under the curb from the face side until it reaches the back, rather than place mortar from both sides. Any void or wooden wedge will later become filled with water and is almost certain to freeze and loosen the curb.

Bituminous curb must be laid on a smooth firm surface, usually hot top or surface treatment, to provide a base for the curb and smooth area for the curb machine. Any rough or poorly graded area under the curb machine will be reflected and magnified in the line and grade of the curb.

SECTION 611 – WATER PIPES

611.1 – GENERAL

The purpose of this item is to provide new or replacement water service when required by adjacent construction activity. Construction and payment for the excavation and backfilling of this item are described in Sections 206 and 603 respectively of the Standard Specifications. Local water department personnel should be invited to the project preconstruction conference to be informed of the Contractor's proposed work schedule and to resolve possible resulting conflicts. Before work begins, the Contract Administrator should identify persons to be notified and establish procedures to be implemented in the event of an accidental pipe break (e.g. turning off certain gate valves to shut down a section of an active water line). Full cooperation between the Contractor and the local utility is a prerequisite if the people affected by a water pipe break are to experience a minimum of inconvenience and the work is to be accomplished in the most effective manner.

611.2 – MATERIALS

Because of the variety of materials available to construct this item, the Contract Administrator should carefully check the materials delivered before their incorporation into the work. Pipe lengths, couplings, and jointing materials should exhibit the proper markings that are required by the Standard Specifications. Any required material

certificates of compliance should also be delivered to the Contract Administrator before start of the work.

611.3 – CONSTRUCTION OPERATIONS

The Contract Administrator and the inspectors should be thoroughly familiar with the Standard Specifications and Special Provision requirements pertaining to this item. When a question of proper practice arises, the Contract Administrator should consult the latest American Water Works Association Standards, which are available from the Hydraulics Engineer of the Highway Design Bureau. Prior to the start of construction, all utility lines in the immediate construction area should be located and sufficiently referenced so that the chance of damage may be kept to a minimum. In the event that water service must be interrupted, the Contract Administrator should make certain that all those persons affected by the interruption are properly notified and cautioned to make alternative provisions during the anticipated interruption interval. Because water pipe construction often involves narrow trench work, the inspector should see to it that the Contractor complies with all safety regulations currently incorporated in the Contract in regard to bracing and shoring. Also during construction, proper precautions should be taken to prevent drain water and other foreign matter from entering the water pipe line because it will subsequently require extensive flushing and disinfecting. Another possible consequence could be infecting, unknowingly, adjacent active water systems, thus, endangering the health of those being served by the systems. In those areas where a local water utility organization exists, the Contract Administrator should seek the organization's advice and cooperation to promote mutual satisfaction after State acceptance of the Contractor's work. The Contractor will reference and record all locations of pipes, valves, tees, etc., on As-Built Plans and provide a copy of the plans to the local utility.

SECTION 612 – SEWER PIPES

612.1 – GENERAL

The purpose of this Item is to provide new or replacement sewer service when required by adjacent construction activity. Personnel of the New Hampshire Water Supply and Pollution Control Commission and local sewer departments should be invited to the project pre-construction conference to be informed of the Contractor's proposed work schedule and to reach a complete understanding of the work to be done. Also, at this time correlation of sewer work with that of other utilities should be planned. Work on sewers often involves modifications or relocation of a portion of an existing system, which requires preplanned coordinated efforts to maintain the operation of the existing facility.

Exploratory excavation should be done by the respective utility at all locations where the sewer is to cross an existing utility, and the exact location of the top and bottom of the existing utility should be recorded to verify that there will be no interference with the designed sanitary sewer system.

A sanitary sewer system is carefully designed to carry a given flow in a specified size pipe installed on a specified grade. Where conflicts occur with other facilities being

constructed on the project, the other facilities should be moved if possible to allow construction of the sewer as designed. If the sewer conflicts with existing facilities and must be altered, then a check with the designer is necessary to determine if a change in pipe size is required for the new flow line grade if a redesign is needed.

612.2 – MATERIALS

All material should be inspected prior to being incorporated into the work. The inspector should also be assured that all materials have been approved for use in the work and that all the required Certificates of Compliance have been received. The Standard Specifications and the Standard Sheets attached to the Plans should be consulted for familiarization of requirements.

612.3 – CONSTRUCTION OPERATIONS

The operations involved in the construction of sewer and soil pipes must conform to the applicable requirements of the Culvert and Storm Drain Section of this manual. The project personnel should be thoroughly familiar with these requirements as well as the requirements of the Standard Specifications and the Special Provisions, which usually contain detailed information from the designer of the system.

Sanitary sewers are laid straight between manholes both in line and grade. To achieve the accuracy required in a system, laser beams are sometimes used. The use of a transit in setting line and grade on each length of pipe is also a common method used to produce an acceptable run of pipe.

Careful attention must be paid to the construction of the joints and bedding of the pipe or the sewer line may not meet the tests that are required by the N.H.D.E.S.

Testing of sewer lines is to be conducted in accordance with the testing procedure outlined in the Specifications or Special Provisions.

The Contractor will reference and record all locations of pipes, connections and etc., on As-Built Plans and provide a copy of the plans to the local utility.

SECTION 614 – ELECTRICAL CONDUIT

614.1 – GENERAL

Prior to the start of conduit work, the inspector should carefully study the Plans, Specifications, and Special Provisions. Layout should be checked in the field as soon as possible to determine if it may be advantageous to alter or change the runs somewhat to avoid obstacles unforeseen during design stages. If a major change in circuitry is desired, the District Construction Engineer and the Traffic Bureau should be consulted. In general, conduit runs should be positioned well away from locations where signs, delineators, guardrail, etc., will later be placed. On new construction, all conduit located under paved surfaces shall be placed prior to placement of any pavement.

614.2 – MATERIALS

In general, the materials shall conform to those specified in the Standard Specifications. Certificates of Compliance are required for any conduit used.

A. Steel Conduit

Steel conduit shall be galvanized standard weight. Each length of pipe shall be legibly marked by rolling, stamping or stenciling to show the name or brand of the manufacturer, ASTM A 53, and the length; for small diameter pipe which is bundled, this information may be marked on a tag securely attached to each bundle. Use the following table for field checking:

Diameter (mm)	Design Wall Thickness (mm)	Minimum Wall Thickness (mm)
78	5.49	4.80
103	6.02	5.26

B. Plastic Conduit

Electrical plastic tubing (EPT) and electrical plastic conduit (EPC), including fittings and joint requirements, shall be made from poly-vinyl chloride (PVC), and shall conform to NEMA TC 2. Conduit shall be labeled with the name of the manufacturer, the size of the conduit, and the words "rigid PVC conduit." These markings shall appear on all lengths of conduit longer than 24" (610 mm), and on the packaging of all conduit shorter than 24" (610 mm).

	Schedule 80 PVC Conduit (EPC)		Schedule 40 PVC Conduit (EPC)		Concrete Encased PVC Tubing (EPT)	
Diam (mm)	Minimum Wall Thickness (mm)	Maximum Wall Thickness (mm)	Minimum Wall Thickness (mm)	Maximum Wall Thickness (mm)	Minimum Wall Thickness (mm)	Maximum Wall Thickness (mm)
50	5.54	6.30	3.91	4.42	N/A	N/A
75	7.62	8.53	5.49	6.15	3.18	3.68
100	8.56	9.58	6.02	6.73	3.81	4.32

614.3 – CONSTRUCTION OPERATIONS

Conduit shall be laid out by the Contractor in sufficient detail so that the proper location, depth and grade can be determined. Pull boxes should not be constructed in depressions since surface runoff will collect at these locations. Pull boxes, mast arm bases, and pedestal bases should be set slightly higher than the surrounding surfaces so that water will not pond over them. Asphalt sealer should not be used when joining precast conduit as it erodes the neoprene covering of electrical wiring. When using steel conduit, care should be taken when making field bends. A hydraulic bender is best, but care must be exercised that the bend is not made too sharp. For 90-degree bends, three to four settings

of the hydraulic shoe are necessary to make a smooth bend without kinks or flat sections. Field cuts should be made with a pipe cutter and be square cut, threaded, free of burrs and tightly screwed together. Cut sections and damaged areas of the galvanizing shall be treated with a cold galvanizing repair system. The ends of the conduit should be suitably referenced to aid in future identification and location. See the instructions regarding conduit in Division 800, Project Records.

SECTION 615 – TRAFFIC SIGNS & DELINEATORS

615.1 – GENERAL

Traffic signs are erected in appropriate locations to control and route traffic and inform motorists of driving conditions.

615.3 – CONSTRUCTION OPERATIONS

As soon as possible, the Contract Administrator should field check sign layout to determine any omissions or necessary changes that might require Contract change orders. The Engineer should inform the Contractor in writing as to any changes in the number or text of signs so that the correct signs can be ordered from the supplier.

Location of the sign is the most important factor. During construction layout, it may be advantageous to alter the Plan location slightly to place the sign behind guardrail or ahead of a tree or utility pole. Each sign location should be checked to determine that sight distance is ample, that the sign will not conflict with any roadway or bridge feature, and that the sign is so positioned to minimize splattering by snow and ice removal. Avoid locating a sign behind a lighting pole that may cause glare on a portion of the face and lessen its effectiveness. On major projects, it is advisable to review sign locations with the Traffic Bureau.

The erection and height dimensions of a sign will be shown on the Standard Sheets in the Plans. In addition, overhead signs require approved shop drawings showing complete installation. Signs in urban areas are usually set high enough to allow pedestrian passage underneath, but consideration should be given to overhang and location near sidewalks and drives.

Sign location shall be staked with the sign code number Contractor for review by the prior to installation by the Contractor. The number of stakes required to give line and grade (height) for the sign installation varies. The skew angle should be outlined with layout stakes so when the sign is properly erected the sign text will not be unreadable due to headlight glare. During layout, constantly be aware of the underground conduits, pipes and other facilities so that posts will not be driven or holes will not be machine excavated into them. Where posts must be placed close to underground facilities, post holes should be hand excavated. Close cooperation with the sign Contractor in regard to timing and method of layout will avoid many problems of stakes knocked out by equipment before they can be used.

The proper use of delineators is thoroughly discussed in the Specifications and on the Standard Sheet in the Plans.

SIGN INSPECTION MEMORY JOGGER

- All signs with a GA or GO designation shall have Type III sheeting for the copy, border and background. No patching allowed. *(615.2.9.1.1, 615.3.2.8, Sign Text Layout Sheet, Note 1)*

- All GA and GO signs shall have their size and manufacturer's date labeled on the front face lower left corner. *(Sign Text layout Sheet, Note 4)*

- GA and GO sign borders shall be rounded at the outside corners except where exit panels and signs meet. *(Approved shop drawings)*.

- When panels are permanently removed from existing signs (including bridge mounted signs) the supports shall be trimmed to match the top of the sign. The supports shall not extend onto auxiliary panels. *(Standard No. PS-1A)*

- Supports for top auxiliary panels shall be aluminum Tee bar and shall extend to the top of the panel and shall overlap the main sign by at least 3 full planks. *(Standard No. PS-1A)*

- Supports for service symbol panels shall be galvanized "U" posts and shall overlap the main sign by a minimum of 2 full planks. *(Standard No. PS-1A)*

- Type A signs installed on I-beams and exit tabs on aluminum Tee bar shall have post clip assemblies on every plank, on each side of the beam or bar as well as at the top and bottom of the sign. *(Standard No. PS-1A)*

- All signs with bolts through the face shall have a nylon washer between the stainless steel fender washer and the sheeting. *(Standard No. PS-2)*

- Signs installed on 4-inch aluminum posts shall have backers extending the full width of the sign minus 6 inches on each end. *(Standard No. PS-2)*

- Spliced U-channels are not allowed. *(Standard No. PS-3)* U-channels shall be galvanized. (*Standard Specifications 615.2.5.3)*

- Breakaway foundations shall have a maximum reveal of 4 inches. ***(Standard No. PS-3, PS-5A, PS-6B)***

- Non-Breakaway foundations shall be finished to match the adjacent slope. ***(Standard No. PS-4A, PS-4B)***

- Sign mounting height shall be measured from the elevation at the edge of pavement to the bottom of the primary sign and shall be as specified in the MUTCD except as modified on the sign text layout sheets. Basically 6' minimum on a conventional roadway in a rural district and 7' everywhere else and for all plank signs. ***(Standard No. PS-4A, PS-4B, PS-5A, PS-5B, Sign Text Layout Sheet Note 7, MUTCD section 2A-18)***

- Hinge points on breakaway I-beams shall be 3 inches below the sign. ***(Standard No. PS-6A "Assemble according to manufacturer's instructions")***

- Invite Bureau of Traffic to a "pre-final" inspection when our items are complete. Notify the Bureau of Traffic if signs and pavement markings are not done when the final inspection is scheduled.

- The following Type "C" signs shall have the following types of sheeting as noted below. All other Type "C" signs shall have Type I sheeting unless otherwise directed in the Sign Text Summary.

MUTCD Designation	**Description**	**Copy**	**Background**
R5-1	"DO NOT ENTER"	Type III	Type III
R5-1a	"WRONG WAY"	Type III	Type III
M3-1i, M3-2i, M3-3i M3-4i, M4-5i	Interstate Shields and auxiliary panels	Type III	Type III
W1-8	Chevrons, Speed Limit > 50 mph	Type I	Type III
W14-3	"NO PASSING ZONE"	Type I	Type III
OM1-3	Type I, Object Markers (yellow)		Type III
OM4-3	End of Road Markers (Red)		Type III
S1-1	School Warning	Type I	Florescent Yellow/Green
W16-7pL, W16-7pR	Supplemental arrow plaques for School crossings	Type I	Florescent Yellow/Green
W16-9P	Supplemental "AHEAD" for School zones	Type I	Florescent Yellow/Green
S4-3	"SCHOOL" plaque for speed limit sign	Type I	Florescent Yellow/Green
S5-1	"SCHOOL SPEED LIMIT WHEN FLASHING" "SCHOOL" portion remainder of sign	Type I Type I	Florescent Yellow/Green Type I
GO and GA Series	All shields, legends, arrows and borders	Type III	Type III

SECTION 616 – TRAFFIC CONTROL SIGNALS

616.1 – GENERAL

The installation of traffic signals can be considered as the erecting, installing, and wiring of specialized equipment to control the flow of vehicular and pedestrian traffic. A Contract is usually let so the work can be accomplished along with the road Contract.

616.3 – CONSTRUCTION OPERATIONS

To coordinate the roadway and signal Contractor's activity relative to signal installation, the Contract Administrator should suggest a plan similar to this order of work:

A. Laying the Conduit Network

Usually conduit is installed by the road Contractor before the signal Contractor begins work. All conduit runs should be tied to prominent field features so as to minimize exploratory digging and should be recorded accurately in a field book.

B. Excavating, Forming & Pouring of the Pull Boxes, Pole Bases & Controller Bases

This is usually the first work accomplished by the signal Contractor. The Engineer should stake the proper location and elevations for signal controller bases, handholes, etc. Important dimensions and detail of boxes and bases are shown on Standard Detail Sheets in the Plans.

When laying out a pole standard and pull box location, the Contract Administrator should ensure that no obstructions exist which will block the sight of the traffic signals or the pedestrian signals. Standards with cross walk pushbuttons should be located close to the sidewalk. Naturally, the location should not be over or too close to underground utilities.

Base and pull boxes should be constructed before the completion of adjacent road Contract items so that topsoil, sidewalks, pavement, etc., can be finished without damage requiring unsightly patchwork.

The Contract Administrator should make certain conduits are properly capped and that reinforcing steel, ground rods and anchor bolts in signal bases and/or boxes stay in position during the placement of concrete. It is important that pull boxes drain water properly. The top of the box should be flush or slightly higher than the surrounding surface – never depressed or in ditches.

C. Detector Loops

These loops are best cut into the binder course of the pavement so that the wearing course covers the saw cuts used to install the loop wire.

D. Erection of the Signal Posts

In erecting light or signal posts, rope slings should be used to reduce the damage to galvanized or finished aluminum surfaces. Any scratches or peeled enamel on any post, signal head or controller cabinet should be touched-up.

If the touch-up enamel does not match the original enamel, the Contractor should repaint the entire post, head or cabinet. After the pole has been properly aligned, base bolts of poles should be checked for tightness.

E. Installation of Power Service

Coordination with the local power utility company will result in proper and timely installation of power service to the controller box.

F. Installing Signal Heads

Adequate clearance for signal poles and equipment should be allowed to prevent damage from trucks turning at an intersection. When pedestrian signal heads are used, the supporting poles should be placed at least 750 mm behind curbs to protect heads.

G. Pulling Cable into the Conduits

Sufficient slack in cables pulled from detectors and poles is necessary to prevent unauthorized splices not shown on the Plans.

H. Wiring and Tagging Signals to Controller

An electrical system is only as good as its conductors, terminals and splicing. Should any question arise pertaining to the technical nature of the electrical work, the Contract Administrator can consult with the Department's Electrical Engineer located within the Traffic Bureau. Color codes as set forth in the Specifications facilitate maintenance. Because of hazards of electrical shock, all grounds and ground bonds referred to on the Plans should be given special attention to ensure a complete and safe installation. Wire splices indicated on the Plans should have the splice sleeves crimped tight and well-soldered. Application of electrical tape under slight tension will result in a neat watertight splice.

I. Checkout of Individual Components and Entire System

Testing of completed electrical facilities includes operational timing tests and tests to determine the quality of the wiring workmanship. Failures of the electrical equipment due to manufacturing defects generally occur within a few days of being placed in operation. Only close inspection and quality workmanship in splicing and attaching connections and grounds will prolong the life and reduce the maintenance of the signal system. Final checkout should be done in the presence of an appropriate member of the Traffic Bureau.

SECTION 618 – UNIFORMED OFFICERS AND FLAGGERS

618.1 – GENERAL

A. Within the limits of the project, all uniformed officers and flaggers required will be paid for as provided in the Specifications.

B. Outside the limits of the project, all uniformed officers or flaggers required at the initial entrance upon a public highway from both gravel and borrow pits will be paid for on the basis of one man per pit. However, where the volume of traffic on the particular public highway is such that the entrance does not constitute a hazard, the officer may be considered to be required at the one location or intersection on the route from the pit to the project that is determined by the Contract Administrator (with the advice of responsible enforcement agencies) to present the greatest hazard to the traveling public.

At any other locations where uniformed officers are required to insure the safety of the traveling public, regardless of whether or not such officers are requested by the State or local enforcement agencies, it shall be the responsibility of the Contractor to furnish them. The Contractor will need to contact the State or Local Police Departments to schedule this detail. It is required that flaggers know their responsibilities, be clothed in a suitable and characteristic uniform including hard hats and blaze orange vests, and be certified to perform the flagging duties. All flaggers are to control traffic with a stop paddle, and two-way radio if needed, subsidiary to the item. The responsibility of setting up a uniformed officer or flagging operation is that of the Contractor. If problems with traffic still occur the field personnel should contact the Contractors superintendent on the project so that he can make changes to the traffic control plan.

SECTION 619 – MAINTENANCE OF TRAFFIC

619.1 – GENERAL

Traffic maintenance is the Contractor’s responsibility, day and night, and it is the Contract Administrator's duty to see that this responsibility is assumed. This item can be broad in meaning. Some examples may include grading and watering the roadway, constructing and maintaining small detours around work areas, setting up and taking down of temporary work signs to notify the public of upcoming traffic patterns, and the paving of cross-pipe patches. The superintendent must be constantly aware of traffic maintenance and should anticipate potential trouble areas, taking necessary action to minimize inconvenience to the traveling public. The Contractor shall assign reliable personnel to this important and continuous part of the work.

At or shortly after the Pre-Construction Conference when the Contractor has a proposed schedule of operations, the type and number of signs required should be reviewed to anticipate what additional signs are needed. This need may change as the project progresses, but advance planning should result in the Contractor having them available when they are required.

The Contract Administrator must have the addresses and telephone numbers of the superintendent and at least the next in command. These numbers are generally obtained at the pre-construction conference and maintained in the project field office for easy reference. A copy of emergency contacts shall be forwarded to the Construction Bureau.

The superintendent should set up a system of recording pertinent data regarding damage to vehicles of the traveling public and all complaints.

All project personnel should be alert to criticisms and suggestions of the traveling public. Although some of these may be unwarranted, some will point out oversights or inadequacies in traffic maintenance. A review of the project during the night time hours is also suggested to assure 24 hour safety.

619.2 – MATERIALS

Where there is a pay item for construction signs, there will be a list on the Plans of the permanent type signs. These are listed by code numbers and the standard sheets show the respective signs. When delivery is made, these signs and controls should be inspected to see that they are in good condition, conform to the standards, and should be checked off to discover any shortages.

An important part of traffic maintenance is dust control. Calcium chloride provides a practical method of dust control on potentially dusty sections of construction areas open to traffic. Its use usually eliminates the nuisance and impediment to heavy traffic caused by water wagons interfering with traffic and eliminates the messy condition of a freshly watered surface that covers the cars and windshields with mud. This is usually not subsidiary to the item, and should be considered as a last resort due to the extra work cost associated with this operation.

619.3 – CONSTRUCTION OPERATIONS

Prior to the start of any construction, signs shall be erected at the beginning and end of the project and at all important connecting roads (i.e. high traffic volumes, limited sight distances, highly populated areas, etc.).

The location of signs and warning devices shall be as specified in the plans and specifications or as designated by the Contract Administrator. The signs shall be erected prior to the beginning of all other work and not removed until all other items of the Contract are complete. Close attention must be paid to the layout to ensure no visibility conflicts occur with driveways, existing signing or signals.

It is the Contract Administrator's responsibility to ensure that the Contractor maintains and properly protects all construction signs necessary to properly warn and safeguard the traveling public. The specifications require the Contractor to be responsible for proper signing on the project. A daily check should be made of the signs on the project and the Contractor should be required to set up or replace any which have been knocked down or damaged.

Before starting an operation that will change the flow of traffic or require different maintenance, the superintendent should discuss the proposed construction signing with the Contract Administrator. The Specifications and the *Manual on Uniform Traffic*

Control Devices for Streets and Highways cover the requirements and should be frequently consulted.

Darkness and fog will create problems that must be given special attention due to greatly reduced visibility. Visit the project under these conditions and trouble spots will show themselves.

Very severe or unusual weather will require that signs be checked by the personnel responsible for maintenance of traffic, i.e. signs may blow over, become covered with snow, or splashed with mud. Oiled surfaces may require additional sand cover, and catch basin grates may become clogged.

Dust is a considerable nuisance as well as a hazard to all, and it is the Contractor's responsibility to furnish labor and equipment for its control. To be immediately effective, calcium chloride requires moisture from the air or ground. When the air is hot and dry, the ground surface should be moistened before the calcium chloride is applied. All necessary grading should be done before application, as the dust-controlling benefits are almost eliminated by regrading. Payment for materials only will be made by extra work.

Locations of skid marks or accidents should be reviewed to determine the cause and what to do to correct conditions.

The safety and convenience of the residents along the roadway must be provided for by the Contractor, who shall be responsible for proper and timely notification of local residents before making interruptions to their roadway access. This works to everyone's advantage as residents are more cooperative when they are notified and understand what is to happen. Often the Contractor learns of some important considerations such as sickness, funerals or some scheduled delivery so that the interruption to access can be timed for the least interference.

In all aspects of signing, the Traffic Bureau stands ready to act in an advisory capacity from the beginning to the final completion of the project. Special circumstances may occur where the Traffic Bureau will provide essential services and materials such as pavement marking on detours and on temporary surfaces as well as approach signs and devices off the project.

The specifications have a sub-section on traffic control for resurfacing projects which describes the requirements of this type of project.

SECTION 622 – WITNESS MARKERS AND BOUNDS

622.1 – GENERAL

Witness markers are for the benefit of highway maintenance so that they may find drainage structures and small culverts that might otherwise be hidden in tall grass, under snow or under high water. The markers should be placed beside culvert ends generally

24” (600 mm) diameter or less, underdrain outlets, and basins that are outside of pavement and lawn areas.

Bounds are set to provide permanent reference points so that the centerline of the roadway and right-of-way lines can be located. The Contract Administrator should receive a set of right-of-way plans showing bound locations. The exact location for each bound will be established from reference stakes normally set by a NHDOT survey party, and these reference stakes shall not be removed until the position of the bound has been checked by Survey Section, Highway Design.

622.3 – CONSTRUCTION OPERATIONS

Generally the bounds are concrete and either buried flush (urban areas) or left 4” to 6” above ground level. When a bound cannot be set because of its location (in riverbed, etc.) a note will be made in the project record book and on the record plan that it has not been set. When a bound cannot be set, but a pin is set, the setting of the pin will also be noted in the project record book and on the record plans. The Contract Administrator shall check with Highway Design prior to making any field changes.

SECTION 624 – RAILROAD PROTECTION

624.1 – GENERAL

This item is to provide the means to reimburse the Contractor for providing protective services for railroad facilities. Usually the Contractor will arrange to secure the protective services from the railroads involved and pay them directly for such services. The amount and type of protective services required is usually stated in the Special Provisions.

624.3 – CONSTRUCTION OPERATIONS

The railroad’s Construction Engineers or inspectors will probably keep in close touch with the work. They should be welcome at all times and given full cooperation in all matters pertaining to the construction. It is the Contract Administrator’s duty to see that all work performed on the railroad company’s right-of-way by a State Contractor is done in such manner as not to interfere with the movement and safety of trains. The Contractor’s working schedule, falsework arrangements, and proposed equipment use should be made known to the proper railroad official. During and after construction, the railroad will be concerned that standard clearances are maintained, that drainage conditions are not interfered with, and that any necessary changes to overhead or buried lines and signals are given due consideration.

SECTION 632 – RETROREFLECTIVE PAVEMENT MARKINGS

632.1 – GENERAL

Pavement markings are normally specified in the plans, and are reviewed by the Traffic Bureau. The specifications for these items are being reviewed quite often so check for Supplemental and Special Provisions.

641.3 – CONSTRUCTION OPERATIONS

Pavement markings should receive special attention to make sure they are laid out correctly as changes after painting are difficult to correct. The majority of work that may affect the markings should be done prior to final marking. The pavement should be clean and dry prior to installing markings. These markings are the "frosting on the cake" and the public will perceive the quality of the job by how it looks.

Any change in layout should be approved by the Traffic Bureau and your District Construction Engineer and follow the MUTCD.

Specifications indicate the method of measurement and tolerances along with reflectivity. The following checklist will assist you in placing markings in a quality manner.

PAVEMENT MARKING MEMORY JOGGER

Standard Plan PM-1

- Passing zones shall always have the single broken line (dual passing) located on the right side of the construction center line when traveling South to North or West to East.

Standard Plan PM-2

- Broken line layout shall be 10' (+/- 2") stripe and 30' (+/- 2") gap. This is also noted in *Specification 632.3.1.3*

Standard Plan PM-3 A & B

- Edge line matching into gore line. Travelway side of the markings shall match into each other.

- Edge (white) and median (yellow) line markings shall be a minimum of 2.5 feet off the curb line or E.P.

Standard PM-7

- 10:1 taper edge lines are only required on the departure and after an intersection when the shoulder is greater than 5 feet unless shown on the plans.

- Stop bars shall end @ the edge line or EP if no edge line.

- Side road edge lines shall not be a continuous line around the corner.

- Centerline breaks shall be continuous past residential driveways. Centerline shall break at Commercial drives with traffic controls (signals & stop signs), minor side roads, intersections with turn lanes.

Other

Pavement marking paint sample according to NHDOT Test Procedure C1
Specification 632.2.1.1

Resurfacing projects Contractor shall provide detail drawings and videotape of the existing pavement markings to ensure the markings are reestablished.
Specification 632.3.1.1.2

Longitudinal and transverse lines shall be straight and true. Standard PM-2 shows tolerances.
Specification 632.3.1.2

Pavement markings shall be applied in one pass at the width specified.
Specification 632.3.1.4

Truck inspections
Specification 632.3.2.1.1

Paint thickness is 20 mils and glass beads applied @ 8 pounds to each gallon of paint. *Spec 632.3.2.4 & 632.3.2.5*

20 mil 4" line = 240 ft/gallon
20 mil 6" line = 160 ft/gallon

Contact Bureau of Traffic to review pavement marking layout prior to striping.

SECTION 641 – LOAM

641.1 – GENERAL

Loam application areas are normally specified in the plans, usually around bridges, interchanges, islands, and next to existing lawns of homes.

641.3 – CONSTRUCTION OPERATIONS

Loam areas around homes should receive special attention to make them attractive and blend well with existing lawns. They should be carefully graded and any transitions from a roadway slope to a flat area should have a smooth rounding that will not be scalped when the grass is mowed.

Any substantial change in areas loamed should be approved by your District Construction Engineer.

Specifications indicate the method of measurement; however, note that if some loam is used from within the project and some is obtained from outside the project, or pit sections, that volume brought in must be kept separate so that it may be added to the item of borrow.

SECTION 642 – LIMESTONE

642.1 – GENERAL

Soils in New Hampshire are normally somewhat acidic and top soil from forested land, swampy areas, and moss covered areas is likely to be the most acidic. The various seed mixtures that are normally used will all benefit by the use of limestone.

642.3 – CONSTRUCTION OPERATIONS

Application by mechanical spreader, except for small areas, will provide the most uniform coverage. The usual application for limestone is 4.5 t/ha (2.0 t/acre) If hydrated lime is permitted, 1.3 t/ha will provide a similar result and the hydrated lime will become effective in a much shorter time. A pH test can be helpful in determining a more accurate application rate. Pulverized limestone generally will absorb into the topsoil quickly, but the effects will be short lived, whereas a pelletized limestone will take longer to absorb, but will be of benefit for a greater length of time.

SECTION 643 – FERTILIZER

643.1 – GENERAL

Fertilizer will be used usually with the topsoil items and with plant materials.

643.3 – CONSTRUCTION OPERATIONS

Fertilizer can be applied by mechanical spreader, hydroseeder, or by hand; however, a mechanical spreader or hydroseeder is best when the size of the area makes them practical. The amount of fertilizer applied should be spot checked occasionally for proper rate of application.

SECTION 644 – GRASS SEED

644.1 – GENERAL

Experience has emphasized several factors which influence the establishment of turf and grass. The most important factor is seed bed preparation, particularly on the heavier glacial tills where finishing operations tend to compact and plane the slope. The soil should be loose and friable, and if possible, 3” (75 mm) to 4” (100 mm) in depth. This is a necessary condition to allow the fine hair roots of grass seed to penetrate the soil deep enough to establish itself. The quantity and quality of topsoil used is another significant factor. Good topsoil supplies organic material, dormant seed, and soil micro-organisms as well as some of the nutrients required for plant growth.

644.2 – MATERIALS

Seeding materials stored on the job should be protected from moisture and rodents. Heat, fuels, and herbicides are detrimental to germination and any such contaminated or improperly stored seed should be rejected.

Check the seed bag tag for proper seed mix and retain at least one tag of each type for the project records.

644.3 – CONSTRUCTION OPERATIONS

It should be determined that the seed bed is properly prepared. (See also Section 641.3 Loam). Where fertilizer is required, it should be applied to the soil at the required rate and worked into the soil during the preparation of the seed bed, unless seeds are sown with a hydroseeder, in which case the fertilizer may be applied in the water along with the seed. The rate of seeding should be checked at the beginning of operations and spot checked thereafter by measuring the area seeded and the actual quantity of seed used, from which the rate of application can be calculated.

Seeds require moisture and warmth to promote germination. Consequently, in order to promote rapid growth, seeds should be sown during the time of year when these conditions are present. Sowing of the seeds in the spring of the year permits the development of turf during the immediate growing season. Seeds may be sown during the summer when a suitable mulch cover is provided to conserve moisture and to protect the seed from detrimental effects of the heat. Generally, seeds require approximately seven to twenty-one days for germination, depending on the species and weather conditions. Some species under favorable conditions may germinate sooner, but unfavorable conditions such as lack of moisture, or insufficient warmth tend to delay germination of all species.

Seeds should not be broadcast if winds prohibit the even distribution of the seed. Drills may be used without regard to the wind. If seeding is done by drills, operation in one direction is normally satisfactory. The inspector should check the depth of seeding, as drills have a tendency to place the seed too deep. Mechanical seeders should produce a satisfactory cover operated in one direction only. When seeding is by hand-operated devices, it should be done in two directions at right angles to each other. Raking or other approved methods is required to cover the seed to the specified depth. Care should be taken to preserve proper seed distribution. Rolling, if required, should be done only to set the seed. It is not the intent to compact the soil. When seeding with a hydroseeder, the seed should be added to the mixture last and not permitted to stand unused for more than four hours, and, in the case of inoculated seed, it should stay in solution more than 30 minutes. Your attention is called to the inoculation of certain seeds appearing in slope seed mixtures as specified in the Standard Specifications. Inoculation should be performed according to the procedure outlined in the Standard Specifications. The use of inoculated seed, as proposed by some seed suppliers, shall not be allowed. The hydroseeder should be thoroughly flushed with clean water at the end of each day's work.

SECTION 645 - EROSION CONTROL

645.1 – GENERAL

Erosion control today must have a very high priority to begin a project and continues to be during the entire construction phase or sequences. Before any construction can begin a Storm Water Pollution Prevention Plan (SWPPP) has to be submitted and approved. The Plan will give the Contract Administrator and Contractor insight and direction as to where and when best management practices should take place. It is quite clear when one can see eroded slopes, filled ditches, plugged pipes and catch basins and turbid streams from a heavy rain event in areas where construction activity has just begun, that evidently, routine daily measures were not installed correctly, properly maintained or installed at al. Being proactive is without a doubt, the best and only course of action to take on a daily basis, being ready and prepared for any weather event that might occur is certainly cost-effective and can prove in the long run to be the least expensive approach ensuring soil stabilization and integrity of water quality.

645.2 – PERMIT PROCESS

For all projects, the permitting process by federal and state agencies involves a field investigation to determine the natural resources or specific site to be disturbed and what impacts the construction activities will have on the environment. Data collected is compiled and reported to regulatory agencies, including other Bureaus of the Department. Documents from the regulatory agencies are then included in a Contract giving important information to both the Contract Administrator and the Contractor.

Contained in the Proposal of a Contract is a Notice of Intent (NOI) document for storm water discharge associated with the construction activity under the National Pollutant Discharge Elimination System (NPDES) from the Environmental Protection Agency (EPA). NOI's must be submitted by the Department and Contractor before construction can start. This essentially lets the EPA know that at this location, starting on an estimated date, an estimated area is to be disturbed. All documents relating to any environmental issue or concern, collectively, are kept in a special file recognized as a Storm Water Pollution Prevention Plan (SWPPP) of the project records. At the completion of the project a Notice of Termination (NOT) from the Department and Cntractor must be submitted to the EPA.

645.3 - CONSTRUCTION OPERATIONS

Mulch will usually be applied with a blower except for small areas. The correct amount of mulch will be the amount that barely hides the ground from view. This will generally be about 4.5 t/ha with blown mulch and 6.7 t/ha with hand placed mulch, but the unit weight of mulch varies to the extent that a visual check is necessary to insure proper coverage. The metric tons per hectare should be checked on one of the first applications and occasionally throughout the work. Too much mulch should not be allowed as it will smother the growth of seed as well as waste the mulch.

Erosion control matting should be placed on a carefully prepared surface so that the matting will make a firm contact with the ground. Be sure to check that the upslope end of the matting is keyed-in by turning down the end and burying at least 6" (150 mm) into the soil. It should not be stretched tight as it will lift over depressions, and it shrinks after the first rain further complicating the problem. After placing and stapling, a lawn roller will help set the matting into the surface of the ground.

Temporary seeding and mulching shall be done on areas that are disturbed in accordance with permit conditions such as Wetlands bureau, Army Corp. of Engineers, NPDES Construction General Permit, or any other state, local and federal permits.

Temporary seeding is an effective means to control erosion, especially on large fill or cut slopes where other methods are impractical or expensive. Seed varieties such as annual rye establish root systems quickly and grow fast, providing good protection. This method of control is very effective where the existing soil will support the growth. If possible, the most cost effective method of control is to cover the slope with humus and establish a permanent growth at an early stage.

Temporary mulch shall be applied to areas of disturbance to stabilize and prevent erosion on slopes and other areas when work is suspended or when an area has not seen any construction activity in 14 days. Hay shall be applied at a minimum of 3.2 tons per acre (8.0 metric tons per hectare) unless otherwise ordered. Blowing chopped hay mulch is permitted provided the Contractor controls the mulching operation as not to infringe on property owners or the traveling public. Tackifiers may be utilized with some temporary mulch options.

645.4 - ENVIRONMENTAL FIELD REPORT

The Environmental Field Report (EFR) form is an important document to help the Department's Bureau of Environment monitor the implementation of mitigation measures that are used in the field as well as to help analyze the measure's effectiveness. There is a long process in the development of environmental mitigation commitments involving various agencies and the public as well as several Department bureaus. It is important that the Bureau of Environment receives feedback from the Contract Administrator as to the effectiveness of the measures implemented. This will help the Bureau of Environment on future jobs in negotiating with environmental groups and obtaining State and Federal permits.

The Bureau of Environment should be invited to pursue involvement in all phases of the project. A representative of that bureau should be present at the Pre-Construction Conference to explain mitigation requirements for the project. The Contract Administrator should invite the representative to visit the project during the course of construction to confirm compliance with the mitigation requirements as well as at the final inspection to make an evaluation of the effectiveness.

The Contract Administrator is requested to fill out the EFR form, carefully making comments on Sections B and C. See sample completed form on the next page. Particular attention should be given to the effectiveness of the mitigation measure used. Also, any

new type of measure or a new product used that was effective or ineffective should be commented on. The EFR form should be received by the Contract Administrator at the start of the project and submitted to the Construction Bureau Office before the final inspection of the project. An intermediate report may also be submitted after the mitigation work has been completed.

NEW HAMPSHIRE DEPARTMENT OF TRANSPORTATION

ENVIRONMENTAL FIELD REPORT

Project _____ **Date** _____
State & Federal No. _____
Project Contract Administrator _____
_____
Contractor _____

A. Erosion Control Plan Yes No
Erosion Control Designer_____
Did the Design Work? Yes No
Did the Planner Show Responsibility for Implementation? Yes No
Comments:_____
___
_____
___
Was the Erosion Control Monitor on Site Regularly? Yes No
Comment on the Effectiveness of the Monitor:_____
_____
___
_____
___

B. Soil Erosion Control and Storm Water Management Measures

Please report on the effectiveness and ease of maintenance of any new, uncommon, unusual or experimental measures that were used *OR* recurring problems with traditional measures.

C. Environmental Commitments Checklist

Attach a copy of the Environmental Commitments Memo (Derived from the Environmental Document). Next to the individual commitment, please note the date it was completed. If the date is unknown, please verify that the commitment has been completed by placing a ✓ next to it. In addition to this, please note any other commitments that do not appear on the Environmental Commitments Checklist.

G:\BUR16\ENVFLDRPT

THE STATE OF NEW HAMPSHIRE
DEPARTMENT OF TRANSPORTATION

Date: February 5, 2004

From: Name
Contract Administrator.

Subject: Letter of expectations and goals

To: Name
Project Monitor

The purpose of this letter is to establish standards, performance expectations, set goals, and to review accountabilities inherent to your position.

As an erosion control monitor, you are expected to perform all accountabilities efficiently and diligently in accordance with section 645 of the standard specifications. As Contract Administrator, I will support and assist you by providing clear guidance. I expect you to regularly communicate both with the contractor and myself. I expect your behavior to be courteous and respectful toward the contractors' employees and the general public.

Once a week and within 24 hours after any storm event greater than one half inch you will conduct an on site review of the projects erosion and sediment control plan. Also, at this time you will provide me with a report stating the time and date of the review, the erosion and sediment controls reviewed and their effectiveness, any deficiencies and corrective actions to be undertaken. Once a week during your review of the project, I'll conduct a brief meeting with you and the projects' superintendent. At this time, we will review the accomplishments of the week and will discuss any outstanding and/or ongoing issues. Also, we will discuss construction operations for the coming week. I shall meet with you weekly to review your performance and to provide guidelines to enhance your work performance as needed. At this time, we will set goals for the next on site review and report.

I expect you to follow the standards and procedures as below:

- You are responsible for weekly on site reviews.
- You shall provide a copy of the weekly reports to the Contractor and myself.
- To prepare accurate reports, you shall inspect all erosion and sediment controls and describe deficiencies and maintenance procedures. If needed, you shall make recommendations to the Erosion and Sediment Control Plan.
- The time charged for the site review shall be in accordance with section 645 of the Standard Specifications, for actual number of hours spent monitoring the site and on site report preparation. Travel time and other time spent **not** at the construction site will not be authorized for payment.

GOALS:

- Provide a detailed weekly inspection report that the Contractor and myself can follow in order to implement an effective and a properly maintained Erosion and Sediment Control Plan.
- To ensure that the Erosion and Sediment measures are functioning properly.
- To ensure all new construction methods and operations have proper erosion and sediment control, and the Plan is kept up to date.

Your performance will be based on the standards and procedures discussed during this meeting, and by the other standards and procedures established by the Bureau of Construction, and the Department. As Contract Administrator I will provide guidance and feedback. I encourage you to feel free to ask for any assistance and guidance as needed to perform your job duties effectively and successfully.

Acknowledgment below certifies that the areas in this letter were discussed in detail. Additionally you have been provided specific examples of performance that would justify "Below expectations" and "Meets expectations" ratings. Thank you for your cooperation and I look forward to working with you.

_____

_____

Project Monitor

Contract Administrator

_____

_____

Date

Date

GENERAL GUIDANCE FOR

STORM WATER POLLUTION PREVENTION PLAN (SWPPP) PREPARATION FOR THE NPDES GENERAL PERMIT FOR STORM WATER DISCHARGES FROM CONSTRUCTION ACTIVITIES

The Construction General Permit (CGP) issued by EPA, authorizes storm water discharges from large and small construction activities that result in a total land disturbance of equal or greater than one acre, where those discharges enter surface waters of the United States or a municipal separate storm sewer system (MS4) leading to surface waters of the United States subject to the conditions set forth in the CGP. The goal of this permit is to reduce or eliminate storm water pollution from construction activities by requiring planning and implementing appropriate pollution control practices to protect water quality.

The CGP requires development of a Storm Water Pollution Prevention Plan (SWPPP). The Department of Transportation (NHDOT) directs its contractors to prepare the SWPPP on its behalf. The following information is provided for general guidance in the development of the SWPPP. Such guidance will be in effect until otherwise noted.

Guidance Documents: A copy of the EPA "Storm Water Pollution Prevention Plan Checklist" is attached for reference. This document was published in 1992. Although it is helpful in developing the SWPPP, it may not be consistent with all the requirements in the 2003 Construction General Permit (CGP).

Components of the SWPPP - A document labeled as a "**SWPPP**" shall be prepared and retained on the project site. The SWPPP shall be comprised of the following components, and the requirements contained therein:

- Erosion and Sedimentation Control and Storm Water Management Plan
- Applicable Special Attentions and Special Provisions contained in the construction Contract
- Applicable Specifications and Supplemental Specifications contained in the construction Contract
- NPDES General Permit for Discharges From Large and Small Construction Activities (CGP) registered on July 1, 2003
- Copy of the owner's and operator's NOI application filed with EPA
- Upon receipt, a copy of EPA's acknowledgement letters, for both the owner and operator, noting receipt of, and administratively complete NOI

- Certification of documents as noted in the permit in Appendix G – Standard Permit Conditions page G-3, Section 11(D) (signed by both contractor and NHDOT??)
- Documentation of permit eligibility related to Federally-listed endangered species (is this contained in the contract?)
- Identification of non-storm water discharges
- Inspection reports

All of the pertinent information noted above shall be contained in one document labeled as a "SWPPP"

Erosion and Sedimentation Control and Storm Water Management Plans: These plans shall be prepared in accordance to NHDOT Standard Specification Section 645. Measures and controls to prevent or minimize pollution of storm water shall include the following controls: erosion and sediment controls, storm water management controls and other appropriate controls:

Making plans available - The SWPPP shall be prepared ***prior to*** the submission of the NOI to EPA. A copy of the SWPPP, NOIs, and acknowledgement letters from EPA must be retained at the construction site.

A sign or other notice containing the following information shall be posted at the construction site:

- Copy of the completed NOIs as submitted to the EPA Storm Water Notice Processing Center.
- If the location of the SWPPP or the name and telephone number of the contact person for scheduling SWPPP viewing times has changed, the current location of the SWPPP and name and telephone number of a contact person for scheduling viewing times.
- The SWPPP is to be kept at the construction facility during the entire construction period. The plans should be submitted to EPA for review only when requested by EPA.

Deadlines: The SWPPP shall be prepared ***prior to*** the submission of the NOI. The construction project must comply with the provisions of the plan throughout the construction period. The plan must be updated as appropriate. Reference the Special Attention (National Pollutant Discharge Elimination System (NPDES) Storm Water Construction General Permit Requirements) regarding the deadlines for submission of the NOI relative to the start of construction activities.

Contract Administrator's Checklist
For
SWPPP Plans and Erosion Control

This checklist has been prepared to provide the field inspector a summary of easy to read, step-by-step requirements relative to Erosion Control and the National Pollutant Discharge Elimination System (NPDES) Construction General Permit (CGP). The following questions are based on information found in the Standard and Supplemental Specifications, appropriate sections of the Construction Manual, and the CGP.

- Have you reviewed the contract Special Provisions, Supplemental Specifications and plans and the CGP? _____

National Pollutant Discharge Elimination System (NPDES) Storm Water Permit.

- Is your project subject to NPDES Permit requirements? _____
- If yes, is a copy of the Storm Water Pollution Prevention Plan (SWPPP) on file at the project site? _____
- Is a copy of the NPDES Construction General Permit (CGP) on file in the SWPPP? _____
- Has a Notice of Intent (NOI) been submitted to the EPA before any disturbance was undertaken? _____
- Has a copy of the EPA's NOI acknowledgement letter for both Owner and Operator been posted at the construction site? _____
- Is the Contractor placing the proposed controls in a timely manner, in accordance with the SWPPP? _____

- Are inspections being conducted every seven calendar days and within 24 hours after a ½ inch storm event and the results reported on the erosion control inspection report?

  _____

- Are the inspection reports being kept with the SWPPP?

  _____

- If an inspection disclosed a violation of the SWPPP, has the violation been corrected? _____

- Has the violation been noted on the following weekly erosion control inspection report?

  _____

- Have you modified the SWPPP as necessary

  _____

- Has a Notice of Termination (NOT) been submitted to the EPA when the project is complete?

  _____

Erosion Control Plan

- Does your project contain temporary erosion control measures and/or Special Provisions or is an Erosion Control Plan required?

  _____

- If yes, do you have a copy of the required approved Erosion Control Plan?

  _____

- The Erosion Control Plan provides for both temporary and permanent erosion controls to protect adjacent property, water courses, wetlands and completed construction. Are you familiar with the Plan?

  _____

- Are those items needing special attention being protected

prior to soil disturbance?

_____

- If yes, have you analyzed your erosion control needs and determined which of the permanent erosion control items you need to supplement with temporary items and when they need to be installed? _____

- Have areas that have not been active for more than 14 days been stabilized? _____

- Has the Erosion Control Plan addressed turbidity limitations to receiving waters?

  _____

- Have cold weather BMP's been addressed?

  _____

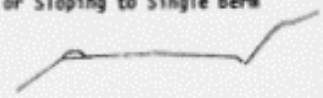
- Is your project ready for forecasted or surprise rain events?

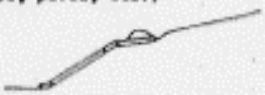
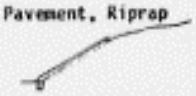
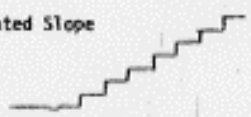
  _____

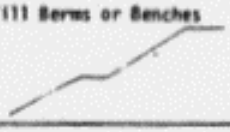
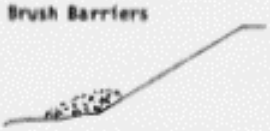
Please keep a copy of this checklist with the project SWPPP.

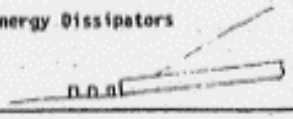
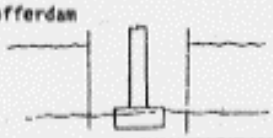
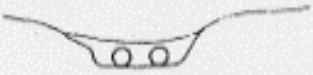
Contract Administrator's signature_____ Date _____

ENGINEERING EROSION CONTROL CRITERIA

Treatment Practice	Advantages	Problems
ROADWAY DITCHES		
Check Dams 	Maintain low velocities Catch sediment Can be constructed of logs, shot rock, lumber, masonry or concrete	Close spacing on steep grades Require clean-out Unless keyed at sides and bottom, erosion may occur
Sediment Traps/ Straw Bale Filters 	Can be located as necessary to collect sediment during construction Clean-out often can be done with on-the-job equipment Simple to construct	Little direction on spacing and size Sediment disposal may be difficult Specification must include provisions for periodic clean-out May require seeding, sodding or pavement when removed during final cleanup
Sodding 	Easy to place with a minimum of preparation Can be repaired during construction Immediate protection May be used on sides of paved ditches to provide increased capacity	Requires water during first few weeks Sod not always available Will not withstand high velocity or severe abrasion from sediment load
Seeding with Mulch and Matting 	Usually least expensive Effective for ditches with low velocity Easily placed in small quantities with inexperienced personnel	Will not withstand medium to high velocity
Paving, Riprap, Rubble	Effective for high velocities May be part of the permanent erosion control effort	Cannot always be placed when needed because of construction traffic and final grading and dressing Initial cost is high
ROADWAY SURFACE		
Crowning to Ditch or Sloping to Single Berm 	Directing the surface water to a prepared or protected ditch minimizes erosion	None - should be part of good construction procedures
Compaction	The final lift of each day's work should be well compacted and bladed to drain to ditch or berm section. Loose or uncompacted material is more subject to erosion	None - should be part of good construction procedures
Aggregate Cover 	Minimizes surface erosion Permits construction traffic during adverse weather May be used as part of permanent base construction	Requires reworking and compaction if exposed for long periods of time Loss of surface aggregates can be anticipated
Seed/Mulch	Minimizes surface erosion	Must be removed or is lost when construction of pavement is commenced

Treatment Practice	Advantages	Problems
CUT SLOPES		
Berm @ top of cut 	Diverts water from cut Collects water for slope drains/paved ditches May be constructed before grading is started	Access to top of cut Difficult to build on steep natural slope or rock surface Concentrates water and may require channel protection or energy dissipation devices Can cause water to enter ground, resulting in sloughing of the cut slope
Diversion Dike 	Collects and diverts water at a location selected to reduce erosion potential May be incorporated in the permanent project drainage	Access for construction May be continuing maintenance problem if not paved or protected Disturbed material or berm is easily eroded
Slope Benches 	Slows velocity of surface runoff Collects sediment Provides access to slope for seeding, mulching, and maintenance Collects water for slope drains or may divert water to natural ground	May cause sloughing of slopes if water infiltrates Requires additional ROW Not always possible due to rotten material etc. Requires maintenance to be effective Increases excavation quantities
Slope Drains (pipe, paved, etc.) 	Prevents erosion on the slope Can be temporary or part of permanent construction Can be constructed or extended as grading progresses	Requires supporting effort to collect water Permanent construction is not always compatible with other project work Usually requires some type of energy dissipation
Seeding/Mulching 	The end objective is to have a completely grassed slope. Early placement is a step in this direction. The mulch provides temporary erosion protection until grass is rooted. Temporary or permanent seeding may be used. Mulch should be anchored. Larger slopes can be seeded and mulched with smaller equipment if stage techniques are used.	Difficult to schedule high production units for small increments Time of year may be less desirable May require supplemental water Contractor may perform this operation with untrained or unexperienced personnel and inadequate equipment if stage seeding is required
Sodding 	Provides immediate protection Can be used to protect adjacent property from sediment and turbidity	Difficult to place until cut is complete Sod not always available May be expensive
Slope Pavement, Riprap 	Provides immediate protection for high risk areas and under structures May be cast in place or off site	Expensive Difficult to place on high slopes May be difficult to maintain
Temporary Cover	Plastics are available in wide rolls and large sheets that may be used to provide temporary protection for cut or fill slopes Easy to place and remove Useful to protect high risk areas from temporary erosion	Provides only temporary protection Original surface usually requires additional treatment when plastic is removed Must be anchored to prevent wind damage
Serrated Slope 	Lowers velocity of surface runoff Collects sediment Holds moisture Minimizes amount of sediment reaching roadside ditch	May cause minor sloughing if water infiltrates Construction compliance

Treatment Practice	Advantages	Problems
FILL SLOPES		
Berms at Top of Embankment 	Prevent runoff from embankment surface from flowing over face of fill Collect runoff for slope drains or protected ditch Can be placed as a part of the normal construction operation and incorporated into fill or shoulders	Cooperation of construction operators to place final lifts at edge for shaping into berm Failure to compact outside lift when work is resumed Sediment buildup and berm failure
Slope Drains 	Prevent fill slope erosion caused by embankment surface runoff Can be constructed of full or half section pipe, bituminous, metal, concrete, plastic, or other waterproof material Can be extended as construction progresses May be either temporary or permanent	Permanent construction as needed may not be considered desirable by contractor Removal of temporary drains may disturb growing vegetation Energy dissipation devices are required at the outlets
Fill Berms or Benches 	Slows velocity of slope runoff Collects sediment Provides access for maintenance Collects water for slope drains May utilize waste	Requires additional fill material if waste is not available May cause sloughing Additional ROW may be needed
Seeding/Mulching	Timely application of mulch and seeding decreases the period a slope is subject to severe erosion Mulch that is cut in or otherwise anchored will collect sediment. The furrows made will also hold water and sediment	Seeding season may not be favorable Not 100 percent effective in preventing erision Watering may be necessary Steep slopes or locations with low velocities may require supplemental treatment
PROTECTION OF ADJACENT PROPERTY		
Brush Barriers 	Use slashing and logs from clearing operation Can be covered and seeded rather than removed Eliminates need for burning or disposal off ROW	May be considered unsightly in urban areas
Straw Bale Barriers 	Straw is readily available in many areas When properly installed, they filter sediment and some turbidity from runoff	Require removal Subject to vandal damage Flow is slow through straw requiring considerable area
Sediment Traps 	Collect much of the sediment spill from fill slopes and storm drain ditches Inexpensive Can be cleaned and expanded to meet need	Do not eliminate all sediment and turbidity Space is not always available Must be removed (usually)
Sediment Pools 	Can be designed to handle large volumes of flow Both sediment and turbidity are removed May be incorporated into permanent erosion control plan	Require prior planning, additional ROW and/or flow easement If removal is necessary, can present a major effort during final construction stage Clean-out volumes can be large Access for clean-out not always convenient

Treatment Practice	Advantages	Problems
PROTECTION OF ADJACENT PROPERTY (continued)		
Energy Dissipators 	Slow velocity to permit sediment collection and to minimize channel erosion off project	Collect debris and require cleaning Require special design and construction of large shot rock or other suitable material from project
Level Spreaders 	Convert collected channel or pipe flow back to sheet flow Avoid channel easements and construction off project Simple to construct	Adequate spreader length may not be available Sodding of overflow berm is usually required Must be a part of the permanent erosion control effort Maintenance forces must maintain spreader until no longer required
PROTECTION OF STREAM		
Construction Dike 	Permits work to continue during normal stream stages Controlled flooding can be accomplished during periods of inactivity	Usually requires pumping of work site water into sediment pond Subject to erosion from stream and from direct rainfall on dike
Cofferdam 	Work can be continued during most anticipated stream conditions Clear water can be pumped directly back into stream No material deposited in stream	Expensive
Temporary Stream Channel Change	Prepared channel keeps normal flows away from construction	New channel usually will require protection Stream must be returned to old channel and temporary channel refilled
Riprap	Sacked sand with cement or stone easy to stockpile and place Can be installed in increments as needed	Expensive
Temporary Culverts for Haul Roads 	Eliminate stream turbulence and turbidity Provide unobstructed passage for fish and other water life Capacity for normal flow can be provided with storm water flowing over the roadway	Space not always available without conflicting with permanent structure work May be expensive, especially for larger sizes of pipe Subject to washout
Rock-lined Low-Level Crossing 	Minimizes stream turbidity Inexpensive May also serve as ditch check or sediment trap	May not be fordable during rainstorms During periods of low flow passage of fish may be blocked

Treatment Practice	Advantages	Problems
BORROW AREAS		
Selective Grading and Shaping	Water can be directed to minimize off-site damage Flatter slopes enable mulch to be cut into soil	May not be most economical work method for contractor
Stripping and Replacing of Topsoil	Provides better seed bed Conventional equipment can be used to stockpile and spread topsoil	May restrict volume of material that can be obtained for a site Topsoil stockpiles must be located to minimize sediment damage Cost of rehandling material
Dikes, Berms Diversion Ditches Settling Basins Sediment Traps Seeding & Mulch	See other practices	See other practices

OTHER MANUALS APPROVED BY THE DEPARTMENT FOR EROSION CONTROL/WATER QUALITY - STANDARD PROCEDURES:

A) Volume III, AASHTO Highway Drainage Guidelines, 1992
B) EPA, Storm Water Management for Construction Activities, September 1992
C) New Hampshire Department of Environmental Services, Rockingham County Conservation District, USDA Soil Conservation Service "Stormwater Management and Erosion and Sediment Control Handbook for Urban and Developing Areas in New Hampshire", August 1992
D) U.S. Department of Transportation, Best Management Practices for Erosion and Sediment Control, June 1995

a/ Highway Research Board, "National Cooperative Highway Research Program Synthesis of Highway Practice No. 18", "Erosion Control on Highway Construction," Division of Engineering, National Research Council, National Academy of Sciences - National Academy of Engineering, pp. 42-46 (1973).

MEMORY JOGGER – CONSTRUCTION
SOIL EROSION AND WATER POLLUTION CONTROL

Are the following items being considered and are adequate protective measures being taken during construction?

1. Control Clearing And Grubbing	Keep the exposed erodible area to a minimum - only C&G area needed for immediate grading.
2. Construct Sedimentation Basin	Construct prior to grading. Control grading so runoff will first enter basin.
3. Job Access And Haul Roads	Control drainage at top of roadway. Locate so runoff does not discharge into stream or drainage.
4. Interceptor and Toe-Of-Slope Ditches	Construct early. Protect adjacent private property.
5. Provide Positive Drainage in Cuts	Crown surface of cut and install side ditches.
6. Crown-Berm-Drain Embankments	Visibly crowned - earth berms with periodic slope drains. Provide drainage through “windows”.
7. Cut to Fill Slope Drainage	Require temporary drain as embankment is built. Use stone, pipe or hose.
8. Early Slope Treatment	Grade and treat cut slopes as cut is made. Embankment slopes no later than subgrade.
9. Ditch Treatment/Ditch Lines	Pave or line immediately after ditch excavation. Treat slopes as soon as ditch is excavated. Install check dams in ditch lines to slow velocity of water.
10. Use Drainage Structures	Make sure ditch grade meets inlet grate. Install lining at inlet.
11. Uncompleted Drainage	Don’t allow! Complete the installation and provide adequate inlet and outlet protection.
12. Drainage Outfall Treatment	Make sure temporary treatment provided before water is discharged. Dumped stone, hay bales.
13. Ditch Transitions and Junctions	Build up far side of ditch and carry far enough downstream.

14.Stream Crossings: (a) Temporary Crossings (b) Temporary Diversions (c) Median Drainage (d) Stockpiling	 Maintaining full channel width, use granular backfill (stone, if available), provide adequate cross drainage. Locate to keep velocity at min. - consider erosion of new channel and treat if necessary. Slope median back from stream or construct sedimentation dam or basin. Early treatment of slopes. Keep stockpiles away from stream.
15.Borrow Pits - Disposal Sites	Require proper grading and drainage. Treat slopes to restore growth. Check haul roads.
16.Work and Storage Area	Don't allow discharge of pollutants into stream. May need sedimentation basins or special treatment.
17.Stage Construction	Provide means for temporary drainage. Make sure all erodible areas are treated.

SECTION 646 - TURF ESTABLISHMENT

646.1 - GENERAL

This item is normally used to establish turf on construction projects. The work consists of preparing the soil and furnishing and applying the specified seed types, fertilizers, and limestone. The project personnel should consult the specifications and requirements of the aforementioned individual items.

SECTION 647 - HUMUS

647.1 - GENERAL

Humus is normally used on all earth slopes that are not loamed. Areas to receive humus should be dressed and the humus spread as soon as possible after completion of earthwork in those areas. This will allow the erosion control measures of seeding and mulching to proceed and a root growth to be established in the least amount of time.

It is generally desirable and beneficial to everyone to obtain all of the humus material possible from sites of proposed roadway excavation and embankments before going outside the project for any humus.

SECTION 648 - SOD

648.1 - GENERAL

This is an item that is well covered by a specification, but the following is a checklist that can be useful in the field.

SODDING CHECKLIST

Before Sodding

See that:

1. All materials are approved.
2. Sod is in good condition and is not stored too long.
3. Areas to be sodded are properly shaped and tilled.
4. Fertilizer and lime are applied as required.

During Sodding

See that:

1. Sod is kept moist and is not damaged by handling.
2. Strips are laid in proper direction.
3. Sod is placed with close joints.
4. Sod is tamped into place.
5. Sod in drainage channels and on steep slopes is secured with pegs or matting.

After Sodding

See that:

1. Sod is kept moist until rooted.
2. Pegs and staples are driven flush with the surface.

SECTION 650 - PLANTING

650.1 - GENERAL

Projects that contain sizable quantities of planting will usually be handled by the Highway Design Bureau, Roadside Development Section.

650.2 - MATERIALS

Where the Contract Administrator is required to inspect plant materials, the following should be helpful. The plant materials should be checked for damaged tips, damaged bark on the main stem, and damaged root systems. Deciduous trees with damaged tips may be salvaged by pruning if the amount pruned is not extensive and the natural shape is not harmed, as pruning about 20% of live wood is desirable at the time of planting.

Balled and burlapped plant material should be handled carefully so that the ball is not broken and the roots are not exposed to the air. If medium and large size plant varieties are delivered with bare roots, bundled in moist moss or the like, they should be placed in a temporary trench with earth covering the roots when they are not to be planted for 48 hours or more. Root systems must be kept moist at all times. Particular attention must be paid to the fine feeder roots as they will die quickly if exposed to the wind and sun.

650.3 - CONSTRUCTION OPERATIONS

Some varieties of plant materials can be successfully transplanted from the wild, especially when small, but in general nursery stock will be required. Where questions arise about planting, the Roadside Development Section may be contacted through your District Construction Engineer for advice and assistance.

SECTION 658 - TRANSPLANTING PLANT MATERIAL

658.3 - CONSTRUCTION OPERATIONS

Transplanting of plant materials often requires more careful treatment than planting from nursery stock. Medium and large trees and shrubs that have been growing undisturbed for many years may have a large extensive root system requiring a much larger ball of earth and roots than normal. Also, these transplanted materials require careful watering for some time in their new location. Consideration should be given to the new locations for the plant materials as changes from dry to damp and light to shade etc., may prove unsatisfactory for some plants. Where questions arise about transplanting, contact the Roadside Development Section through your District Construction Engineer. (See also Section 650 - Planting).

SECTION 698 - FIELD FACILITIES

698.1 - GENERAL

The Specifications and Special Provisions sufficiently cover the requirements for the Field Office and the Physical Testing Laboratory. These specifications will vary greatly depending on the size and location of the project.

The fireproof file cabinet should be used for all project records and left locked every night.

Required equipment and toilet facilities should be in operating condition prior to payment on estimates. The field office computer shall also be complete and fully functional. The Contractor shall make arrangements for the installer to connect with the Construction Bureau Office through the CMS Administrator and verify that all hardware and software are operating optimally.

Inventories should be taken of laboratory equipment when the facility arrives and again upon departure. This inventory should be filed with the Contract records. No payment should be made on field facilities and the Contractor should not be allowed to start

earthwork until all equipment specified in Section 698 of the Standard Specifications or Special Provision Addenda is complete.

Note that the Specifications provide that "payment for this item will be made periodically as determined by the Engineer, based on the anticipated length of the construction period". This means that if this is a unit item in your contract that payments will be made incrementally throughout the life of your project. The newer projects will see the Field Facilities paid on a weekly time line. The item will be bid per week based on an estimated amount of weeks. For this reason, it is extremely important that all required equipment and supplies be accounted at the beginning of the job and that phone and electricity be operational.